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Rivers at Risk

Dams and the future of freshwater ecosystems

prepared in cooperation with the World Resources Institute

Contents:

Executive Summary

This report analyses the construction and planning of dams on a river basin scale and examines the risks of dams to freshwater ecosystems. It identifies 21 river basins at severe risk of ecological degradation as they have six or more dams over 60 m high planned or under construction in addition to existing dams. Top of the list is the Yangtze River Basin in China with 46 dams, followed by the La Plata River Basin in South America with 27 and the Tigris and Euphrates River Basin with 26, most of these in Turkey. Of particular concern are the cumulative impacts of large numbers of dams in the same basin, especially in smaller basins such as the Salween/Nu River in Myanmar and China.

Dams are both a blessing and a curse. While they provide water and power, they also cause serious damage to freshwater ecosystems, affecting both nature and people. Already, in 60% of the world's major rivers flows are interrupted by dams, canals and diversions. Many freshwater habitats and species have been lost, with dams and their associated infrastructure, such as irrigation systems, a major culprit.

Dam construction has mainly shifted from the developed to the developing world, with countries such as China and India implementing large dam construction programmes, including interbasin transfers. While water and energy requirements in developing countries are real and need to be addressed, the risk to ecosystems is acute and unique species and habitats are threatened. Migratory fish, river dolphins and water birds are particularly vulnerable, as are the people who depend on these ecosystems for their livelihoods, for example through fisheries. Those most affected by dams still rarely benefit directly and often remain without access to power and clean water. Meanwhile, too much of the water provided by dams is wasted, especially by inefficient agricultural irrigation systems.

To avoid large-scale damage, decision-making needs to be informed by a comprehensive assessment of all options, alternatives and impacts. This should include careful site choice, a cumulative assessment of dams by river basin, as well as extensive mitigation measures for those dams that are given the go-ahead. 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. The World Commission on Dams (WCD) has provided a set of recommendations to improve decision-making on dam development, but these are still not implemented in most countries. Without an effective assessment of options and alternatives, there is a real danger that many current dam projects will have unacceptable and unnecessary costs, repeating the mistakes of past projects that, according to the WCD, often could have been avoided. Best practice examples from around the globe demonstrate that it is possible to strike a balance between water and energy needs and environmental protection. WWF is calling on governments and dam developers to follow these examples by applying the WCD recommendations and cumulative environmental impact assessments. It is their responsibility to 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.

I. Introduction

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. Commitments such as the Millennium Development Goals aim to address this energy and water poverty. As the pressure to solve water and electricity demands grows, dams are being considered by many decision-makers as a key solution. Furthermore, commitments to reduce greenhouse gas emissions under the Kyoto Protocol provide new incentives for developing hydropower dams.

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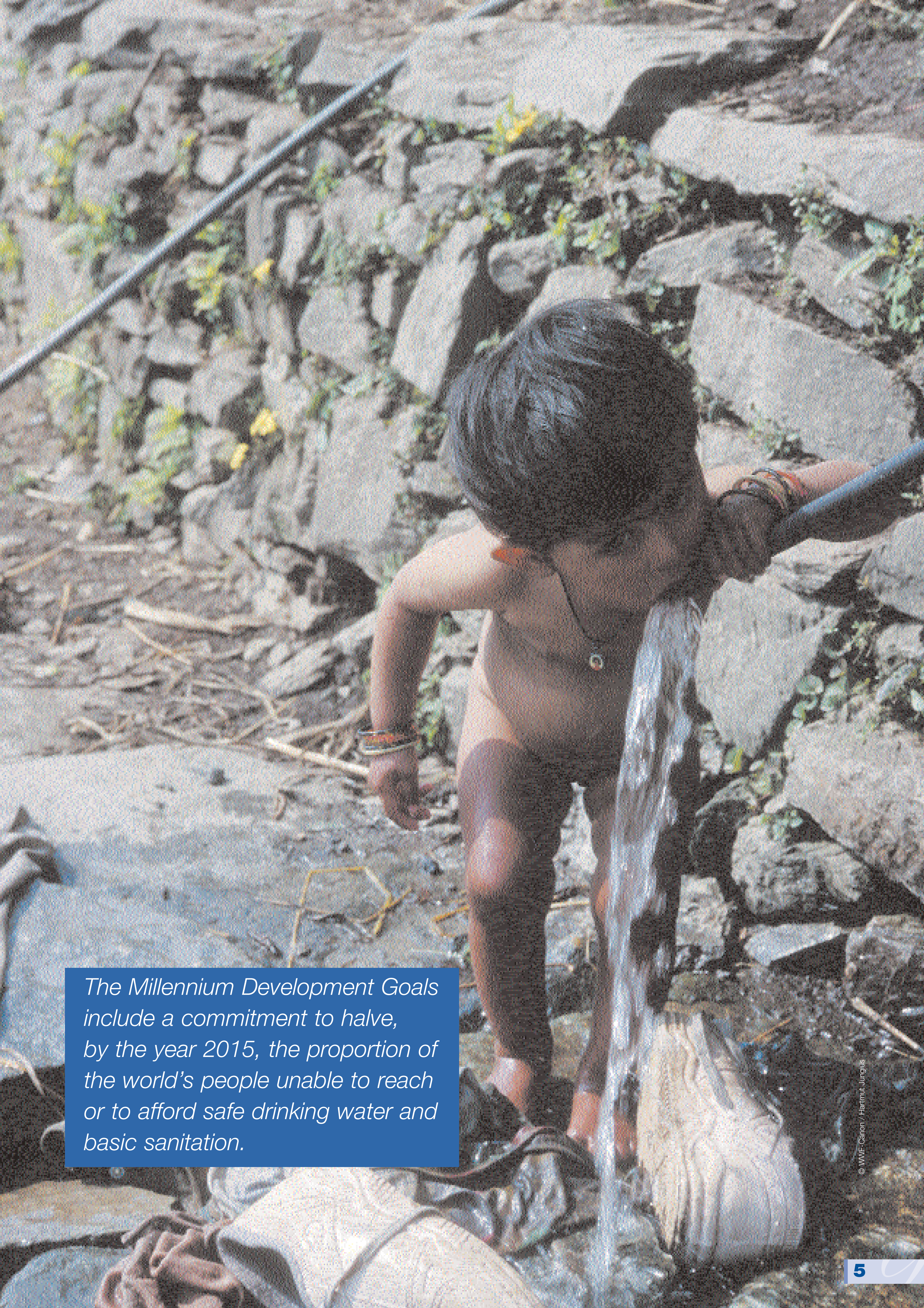
The International Commission on Large Dams (ICOLD) defines a large dam as being over 15 m high. The definition also includes dams between 5-15 m high with a reservoir exceeding 3 million cubic meters.

Globally, more than 45,000 large dams are operational in over 150 countries (WCD, 2000) and another 1500 or so are currently under construction. There is little doubt that dams have improved agricultural output by making more land suitable for cropping through 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 culprit in the decline of freshwater biodiversity observed in recent decades. Over 60% of the world's major rivers are now fragmented, wetlands have been drained and many fisheries decimated.

So, as the world faces increasing water stress and an uncertain climatic future, how necessary are dams for development? Can they be developed in a way that ensures that the benefits outweigh the social and environmental costs? And what role can large dams play in meeting sustainable development goals? The World Commission on Dams (WCD) report (WCD, 2000) has sought to analyse these questions, putting many of the issues related to dams and sustainable development into perspective. It has made specific recommendations to improve the planning, construction and operation of dams. Managing existing and proposed large dams towards a goal of sustainable development and reducing poverty will hinge on a careful balancing of economic considerations and social and environmental impacts. Current dam building programmes target river basins, such as the Yangtze or the Amazon, which are of global biodiversity significance. If no balance can be struck the costs for people and for nature could be enormous.

This report looks at the implications of dam construction for the world's major river basins, with a particular focus on the impacts on freshwater habitats and species and the people who depend on these ecosystems for their livelihoods. It uses the number of dams over 60 m high that are currently planned or under construction in each basin as an indicator of risk to river basins. The analysis shows that the current pattern of planned large dams and dams under construction is concentrated in a relatively small number of basins, many of which have high biodiversity values. These valuable habitats and species are at risk of disappearing from the combined effects of not only one, but multiple dams, sometimes spread throughout the basin, but sometimes on the same river.

Data on new dams is difficult to obtain and the picture presented here is only a partial one. In reality, more dams are being planned and consequently the threat to biodiversity is likely to be even more extensive. However, unacceptable damage can often be avoided or mitigated and this report presents a number of good practice case studies, some focusing on improving decision-making, others on environmental mitigation. The river basin analysis, the case studies, and the recommendations presented here aim to further illuminate the debate over the role of large dams in achieving sustainable development. In particular, the report pinpoints specific regions requiring urgent attention, and aims to provide a clearer picture of the potential risks and what can be meaningfully done to address these risks.



The Millennium Development Goals include a commitment to halve, by the year 2015, the proportion of the world's people unable to reach or to afford safe drinking water and basic sanitation.

II. Socio-economic costs and benefits of dams

Large dams have played an important role in social and economic development, as they provide water for agriculture and hydroelectricity generation. Half of the world's large dams were built primarily for irrigation, and an estimated 30-40% of the 271 million hectares of irrigated lands worldwide rely on dams. In total, dams are estimated to contribute water to 12-16% of world food production. Hydropower currently provides 19% of the world's total electricity supply, with relatively low greenhouse gas emissions, and as a secure source of water supply, dams also play an important role with 12% of large dams designated for water supply (WCD, 2000). Furthermore, many dams have been built for flood control, saving countless lives. Many dams are multi-purpose, serving several of the above functions. However, this may lead to conflicting situations, for example when reservoir levels are kept high for electricity production, reducing their capacity for retaining floodwaters.

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The efficiency of irrigation techniques is low and globally up to 1500 trillion litres of water are wasted annually

To attract investors, many dam projects are developed with the export of electricity to more developed countries in mind, to enable them to recoup their investments as well as make a profit.

However, as the WCD report observed, the effectiveness of large dams has by no means been optimised, raising the question of whether actual benefits match those predicted. Irrigation dams for instance have tended to under-perform in terms of the benefits advocated. Beyond the dam itself 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 needs to be addressed urgently.

Large dams are also very capital-intensive and can be a drain on the national economy, especially in the poorest countries, which tend to have the biggest need for affordable water and energy supply. In the case of hydropower every megawatt of installed capacity costs around US$1 million. To attract investors, many dam projects are developed with the export of electricity to more developed countries in mind, to enable them to recoup their investments as well as make a profit. The planned Mphanda Nkuwa project in Mozambique would thus provide electricity to the Southern Africa Power Pool and Nam Theun II in Laos would provide electricity to Thailand. Both projects are planned with an installed capacity of just over 1000 MW and require an investment of over US$1 billion. These sums dwarf the budgets of these countries. For example, in 1999 Laos had revenues of an estimated US$211 million and Mozambique had revenues of US$393 million in 2001.

Proponents of these projects argue that investment in large-scale projects will contribute to development, if not directly then through the 'trickle down' effect. However, in reality, it is questionable whether these investments are the most effective way to achieve development goals for the poorest and neediest parts of these societies. The 'economic growth trickle down' development thinking is increasingly coming under criticism. For example, the World Commission on the Social Dimension of Globalisation (2004), while recognising that social progress for the poorest countries cannot be separated from economic development, has argued that economic progress by itself does not necessarily mean social progress. While projects can, in principle, make up for the failure of 'trickle down' by specific provisions for benefit sharing and poverty reduction, too often this is not the case.

At the same time there are significant direct and indirect social impacts associated with the construction of large dams. The direct social impacts are associated with human population displacement. The construction of dams and storage reservoirs requires large areas of land to be flooded, sometimes productive agricultural land or land which has historic or cultural significance and often land occupied by villages or communities. Displacement is not uncommonly forced and, whether forced or voluntary, there are usually social impacts associated with resettlement. The WCD estimated the overall global level of displacement by dams to be between 40 and 80 million people (WCD, 2000). In China official statistics cite 10.2 million displaced people by dams between 1950 and 1990 (ADB, 1999). It is likely however that the actual figure is much higher. The Three Gorges Dam project alone has an official displacement figure of up to 1.2 million people. In an increasingly populated world competition for resources and land becomes more acute, making it progressively more difficult to find potential dam sites with limited or no population impacts. Equally it is becoming more difficult to find suitable land to compensate displaced people, without causing conflicts with established communities in resettlement areas. Resettlement of rural populations in more urbanised areas can cause a whole new range of social problems.

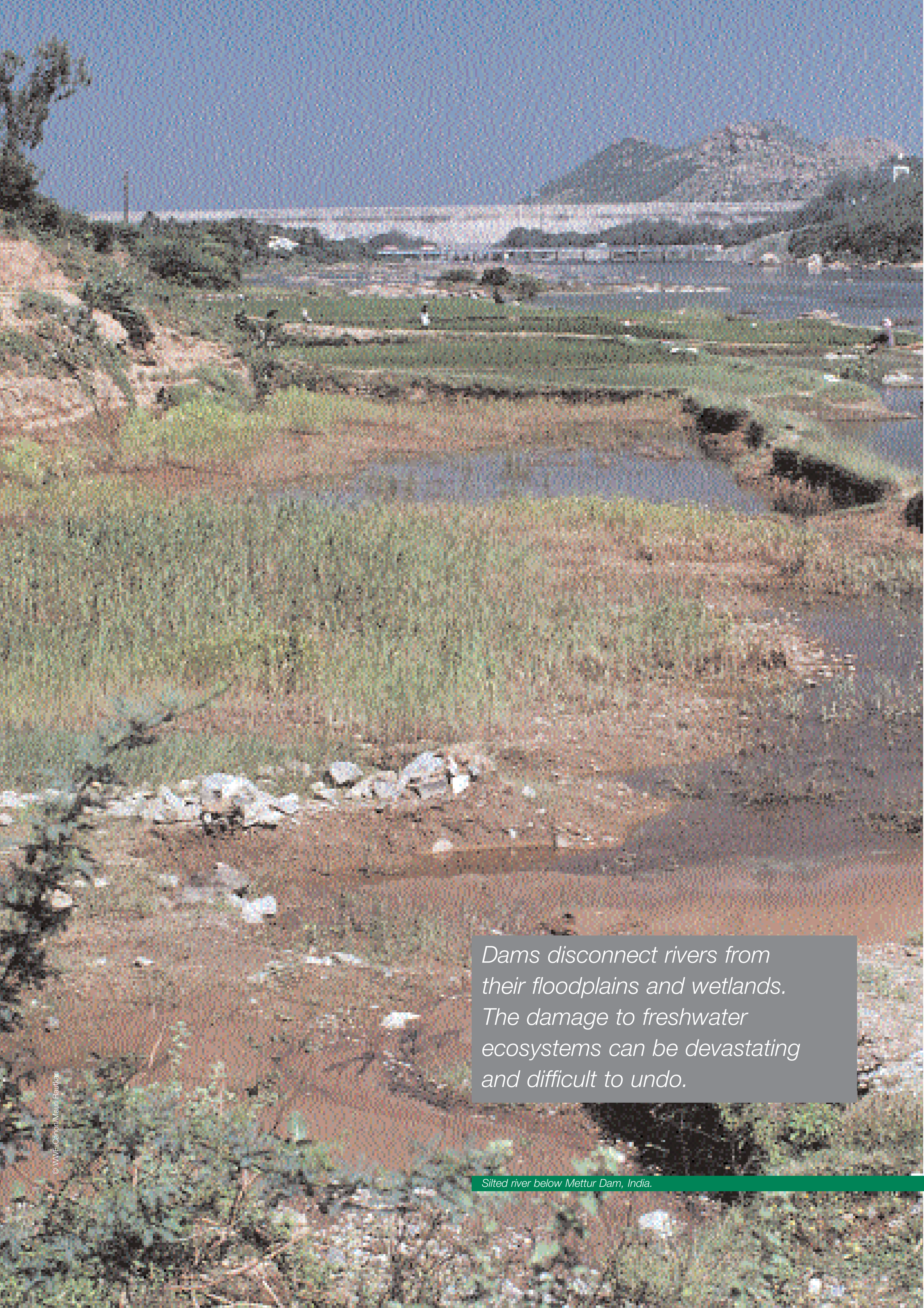
There is also a range of indirect impacts associated with large dams. Communities living downstream from dams, particularly those reliant on natural floodplain functions for their livelihoods such as agriculture, herding and fisheries, suffer the most when dams are built upstream. For example, in northwestern Nigeria, the Bakolori Dam on the Dokoto River reduced its average flood levels by 50%, leading to a 53% decrease of cropped area (Adams, 1985). In the case of the Manantali Dam on the Senegal River, between 500,000 and 800,000 people no longer have access to productive floodplains that provided much of their livelihood (Horowitz et al., 1994).

Local fisherman in the flooded savanna near Lake Chad. Floodplains provide valuable fisheries

Another example is the Tocantins River in Brazil where after construction of the Tucurui Dam the fish catch per invested effort dropped by about 60%, causing the number of fishermen to fall dramatically (Odinetz-Collart, 1987 as cited in Fearnside, 1999). These downstream impacts go to the heart of managing river basins in their entirety, especially when additional complications from transboundary watersheds arise.

In terms of international co-operation for watershed management, upstream players have been significantly more resistant to co-operation as they have less of a perceived vested interest to do so. Two examples of this are the Mekong River Commission where China, the most upstream country, has opted not to become a member and the Senegal River Basin, where Guinea is not a party to the Organisation pour la Mise en Valeur du Fleuve Sénégal (OMVS, the River Basin Organisation of the Senegal River Basin).

Thus economically, dams have brought many benefits but not without social costs. One problem is that little attempt is made to systematically incorporate factors that are seen traditionally as externalities, although this is changing. Where non-market values are incorporated it is usually done in a descriptive, qualitative fashion, which has limited utility in the quantitative cost-benefit analysis framework. As a consequence, a strictly economic approach (without incorporation of these 'externalities') results in a bias in favour of the dam development, although from a sustainable development standpoint the results of such analyses are inadequate.



Dams disconnect rivers from their floodplains and wetlands. The damage to freshwater ecosystems can be devastating and difficult to undo.

Silted river below Mettur Dam, India.

III. Environmental impacts of large dams

The environmental impacts associated with large dams are well documented, and recently there has been an increased emphasis on the social and economic effects of these environmental impacts. These impacts vary in extent and gravity, but it should be stressed that the impacts of large dams are often basin-wide.

Dams disconnect rivers from their floodplains and wetlands and reduce the speed at which water flows in rivers. They impact on the migratory patterns of fish, and flood riparian habitats, such as waterfalls, rapids, riverbanks and wetlands (Dynesius and Nilsson, 1994). These habitats are essential feeding and breeding areas for many aquatic and terrestrial species and they contribute significantly to maintaining other ecosystem services, such as water purification. Dams also affect the migratory patterns of fish, even if fish ladders are installed, as these are only effective as a mitigation measure for a limited number of species, such as salmon.

By slowing the movement of water dams prevent the natural downstream movement of sediment to deltas, estuaries, flooded forests, wetlands, and inland seas, affecting species composition and productivity. Coastal fisheries, for example, depend on upstream inputs to replenish nutrients. After the Aswan High Dam was built on the Nile River, the supply of phosphate and silicate to the coastal area was reduced to 4% and 18% respectively of pre-dam conditions. This drop in nutrients, combined with increased salinity in the delta because of a reduction in the Nile outflow and overfishing, reduced the productivity of the coastal fisheries significantly (FAO, 1995).

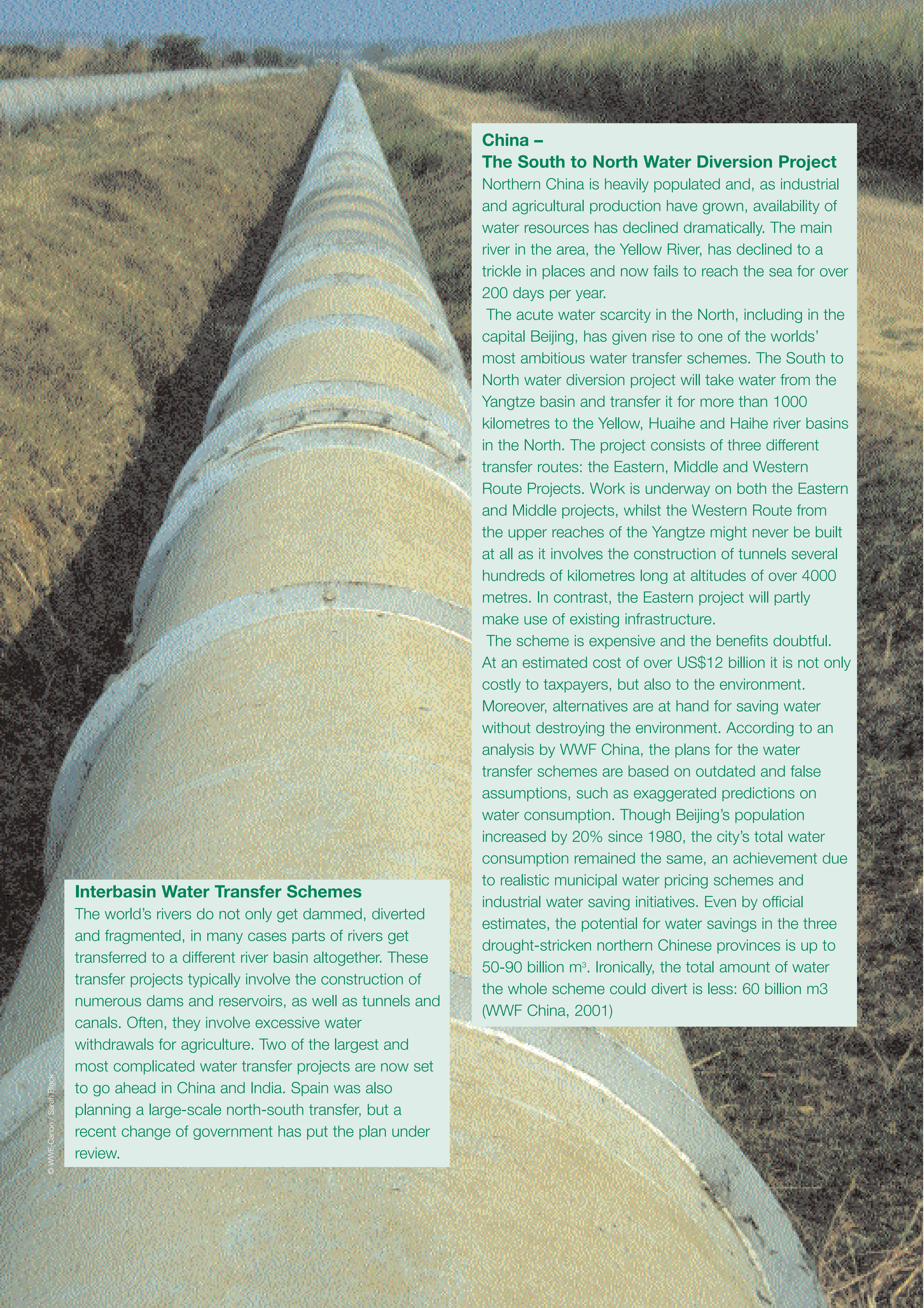
Sediment retention can also interfere with dam operations and shorten their intended lifespans. In the United States, about 2 km^3 of reservoir storage capacity is lost from sediment retention each year, at a cost of US$819 million annually (Vörösmarty et al., 1997). Sedimentation remains an unresolved problem associated with dam management and operation, a challenge acknowledged by the energy and dam industries (International Hydropower Association et al., 2000).

Water retention by dams eliminates or reduces spring runoff or flood pulses that often play a critical role in maintaining downstream riparian and wetland ecosystems. When dams interrupt these pulses, riparian and wetland habitats and associated species are lost (Abramovitz, 1996). Dam operations also influence water quality. Older dams, for instance, tend to release water that is stored at the bottom of the reservoir, which is typically colder and adversely affects species adapted to warmer temperatures. Changes in levels of dissolved oxygen and nutrients also impact on downstream fish species. The artificial timing and volume of releases from large dams play a role as well because they rarely replicate the natural flooding cycles of the natural river system.

Finally, water and sediment retention affect water quality and the waste processing capacity of rivers (the ability to break down organic pollutants). The slow-moving water in reservoirs is stratified into layers instead of being well mixed, with the bottom waters of the reservoir often depleted of oxygen. These oxygen-starved waters can produce toxic hydrogen sulphide gas that degrades water quality. In addition, oxygen-depleted waters released from dams have a reduced capacity to process waste for up to 100 kilometres downstream because the waste-processing ability of river water depends directly on its level of dissolved oxygen (Revenga et al., 2000).

It should also be noted that impacts are not limited to those of the dam itself but are also caused by its associated infrastructures such as access roads to the construction site, power transmission lines or irrigation canals. Dams are often part of regional development plans where many dams are placed within the same basin or where water is transferred from ‘water rich’ basins to basins with water scarcity. The increasingly large scale of these interbasin water transfers causes serious environmental problems.

All of these impacts have led to an unprecedented loss of freshwater biodiversity and decreased the capacity of aquatic ecosystems to produce goods and services upon which people depend. Although is it not possible from current data to determine the relative impacts of dams, as compared to agriculture or urban development, it is clear that dams and associated infrastructure such as canals and irrigation schemes make a major contribution to the degradation of freshwater ecosystems.



China – The South to North Water Diversion Project

Northern China is heavily populated and, as industrial and agricultural production have grown, availability of water resources has declined dramatically. The main river in the area, the Yellow River, has declined to a trickle in places and now fails to reach the sea for over 200 days per year.

The acute water scarcity in the North, including in the capital Beijing, has given rise to one of the worlds' most ambitious water transfer schemes. The South to North water diversion project will take water from the Yangtze basin and transfer it for more than 1000 kilometres to the Yellow, Huaihe and Haihe river basins in the North. The project consists of three different transfer routes: the Eastern, Middle and Western Route Projects. Work is underway on both the Eastern and Middle projects, whilst the Western Route from the upper reaches of the Yangtze might never be built at all as it involves the construction of tunnels several hundreds of kilometres long at altitudes of over 4000 metres. In contrast, the Eastern project will partly make use of existing infrastructure.

The scheme is expensive and the benefits doubtful. At an estimated cost of over US$12 billion it is not only costly to taxpayers, but also to the environment. Moreover, alternatives are at hand for saving water without destroying the environment. According to an analysis by WWF China, the plans for the water transfer schemes are based on outdated and false assumptions, such as exaggerated predictions on water consumption. Though Beijing's population increased by 20% since 1980, the city's total water consumption remained the same, an achievement due to realistic municipal water pricing schemes and industrial water saving initiatives. Even by official estimates, the potential for water savings in the three drought-stricken northern Chinese provinces is up to 50-90 billion m^3. Ironically, the total amount of water the whole scheme could divert is less: 60 billion m3 (WWF China, 2001)

Interbasin Water Transfer Schemes

The world's rivers do not only get dammed, diverted and fragmented, in many cases parts of rivers get transferred to a different river basin altogether. These transfer projects typically involve the construction of numerous dams and reservoirs, as well as tunnels and canals. Often, they involve excessive water withdrawals for agriculture. Two of the largest and most complicated water transfer projects are now set to go ahead in China and India. Spain was also planning a large-scale north-south transfer, but a recent change of government has put the plan under review.

India – Interlinking Rivers

With its periodic and often severe droughts, India is another country looking to interbasin transfers to sustain its burgeoning population and meet food needs.

The transfer scheme in India at present considers 30 possible linking projects, 14 in the Himalayan component and 16 on the Peninsula. Amongst many others, the peninsular component will include the interlinking of the Mahanadi, Godavari, Krishna, and Cauvery rivers, where water from the Mahanadi and Godavari rivers will be transferred to the south. Interlinking the west flowing rivers north of Bombay will help the city's water supply as well as irrigation in the coastal areas of Maharashtra and the interlinking of Ken and Chambal rivers will provide a water grid for Madhya Pradesh and Uttar Pradesh. The Peninsular development is expected to provide additional irrigation of about 13 million hectares and is expected to generate about 4000 MW of power.

The Himalayan Rivers Component focuses on the construction of reservoirs on principal tributaries of the Ganges and the Brahmaputra in India and Nepal, and a canal system to transfer surplus flows to western parts of India. According to the government these schemes would provide irrigation of about 22 million hectares, generation of about 30,000 MW of hydropower as well as provide flood control in the Ganges-Brahmaputra basin.

Debate is alive in India. The Ministry of Water Resources has set up a Task Force on Interlinking of Rivers to examine all aspects of the project. The National Civil Society Committee on Interlinking of Rivers is now firmly established to facilitate a national dialogue. The committee includes both experts who publicly support the project and those who are critical and its purpose is to facilitate a national debate on the technical, social, economical, environmental, and ecological aspects of the project. WWF India is actively involved in the process and will be providing crucial water policy related support.

Sceptics of the transfer scheme promote an exploration of alternatives, thorough assessment of environmental impacts and equitable benefits if the plan is implemented. In many cases it is possible to solve water supply problems not by making more water available but to look at current usage and see if it can be improved in terms of both distribution and application. In other cases, supply can be augmented with the use of local, socially controlled and environmentally friendly approaches. For example, rainwater harvesting techniques and watershed development processes have proved very successful in many parts of India.

Spain – National Hydrological Plan

In Spain the Spanish National Hydrological Plan (SNHP), approved by the Spanish government in July 2001, includes plans for water transfers from the Ebro River to the southeast region of Spain up to 900 kilometres away. This means that besides the existing 40 dams and 6 dams over 60 m high under construction, 44 more dams of over 20 m high are planned along the Ebro River.

The SNHP was conceived as a solution to address the differences in water balance across Spain - by transferring water from river basins that have water 'in excess' to river basins with a 'water deficit'. The Ebro water transfer to another four basins in the east of Spain is the largest part of the SNHP and it would require the construction of approximately 381 new water infrastructures and other works affecting all five river basins. The most negative of these works are six new dams in the high Pyrenees Mountains. The impacts from the water transfer on the Ebro River Basin could ultimately include the total disappearance of the Ebro Delta, an area to be designated under the European Union's Habitats Directive, a Ramsar site and the third most important wetland in Spain.

The SNHP is based on an outdated approach that considers water as an unlimited resource and is, therefore, against the objectives and requirements for sustainable water management included in the EU Treaty, the EU Sustainable Development Strategy and the EU Water Framework Directive. In addition, the project is not economically justified and will be a misuse of European funds and ultimately taxpayer money. Finally, there are many alternatives that reduce the need for these transfers, including modernisation of irrigation systems and urban water savings as well as more technical solutions such as desalinisation of seawater.

The well-founded arguments provided against the SNHP had results when a new Spanish government was elected in March 2004 and ordered a review of the entire workings of the Spanish National Hydrological Plan. The Ebro Transfer was cancelled altogether.

One measure that can be used as a proxy for the impact of dams, canals, and water withdrawals is the level of river fragmentation and flow regulation at the river basin level. An assessment of 227 of the major river basins in the world showed that 37% of the large rivers are strongly affected by fragmentation and altered flows, 23% are moderately affected, and 40% are unaffected (Revenga et al., 2000). In all, strongly or moderately fragmented systems account for nearly 90% of the total water volume flowing through the rivers analysed. The only remaining large free-flowing rivers in the world are found in the tundra regions of North America and Russia and in smaller coastal basins in Africa and Latin America. It should be noted, however, that considerable parts of some of the large rivers in the tropics, such as the Amazon, the Orinoco and the Congo, would be classified as unaffected rivers if an analysis at the sub-basin level were done. The Yangtze River in China, which was classified as moderately affected, has since become strongly affected with the filling of the Three Gorges reservoir.

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The building of access roads to the construction site of the Xiaowan dam on the Upper Mekong (Lancang) river in China has already caused considerable damage.

Where there are a number of dams on the same river, the impacts on water quality and species composition and the disruption of natural river flow accumulate. Problems may be magnified as more large dams are built in a river system, resulting in an increased and cumulative loss of natural resources, habitat, environmental sustainability and ecosystem integrity (WCD, 2000). Ecologically, fragmentation is a problem as maintaining connectivity on all levels is essential to conserve freshwater biodiversity. This includes connectivity between and within aquatic habitats, connectivity with the riparian zone and floodplains and connectivity with subterranean systems (Abel et al., 2002). The loss of connectivity between different parts of a river basin fundamentally alters ecosystem processes and negatively affects species. So, whilst the conservation of discrete freshwater sites, such as a lake or a stretch of river, is undoubtedly valuable, it is an incomplete solution to protecting biodiversity on a basin level. This is particularly true for species that migrate over long distances such as the giant catfish *(Pangasianodon gigas)* in the Mekong basin. Once an important fishery in Northern Thailand, no giant catfish has been caught there since 2001.

River fragmentation continues at a rapid pace and the next section analyses how dam projects currently under construction or planned will affect the world's river basins. It shows that a number of river basins which are currently still in a fairly natural state, are being affected by major development schemes. These pose new threats to freshwater ecosystems which need to be urgently addressed.

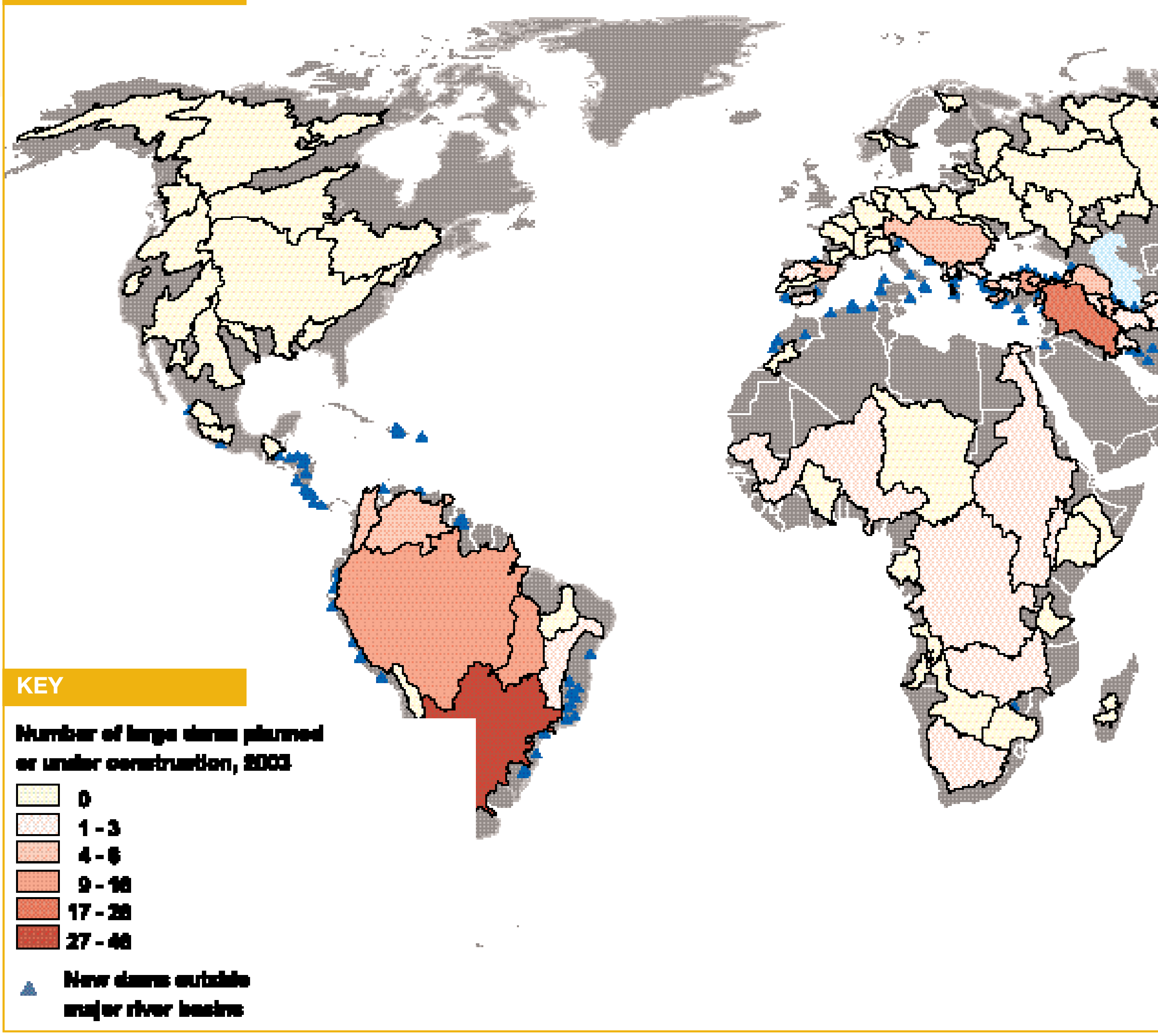
The dry riverbed of the Danube at Dunakiliti, caused by construction of the Gabcikovo dam, Hungary.

IV. Rivers at Risk

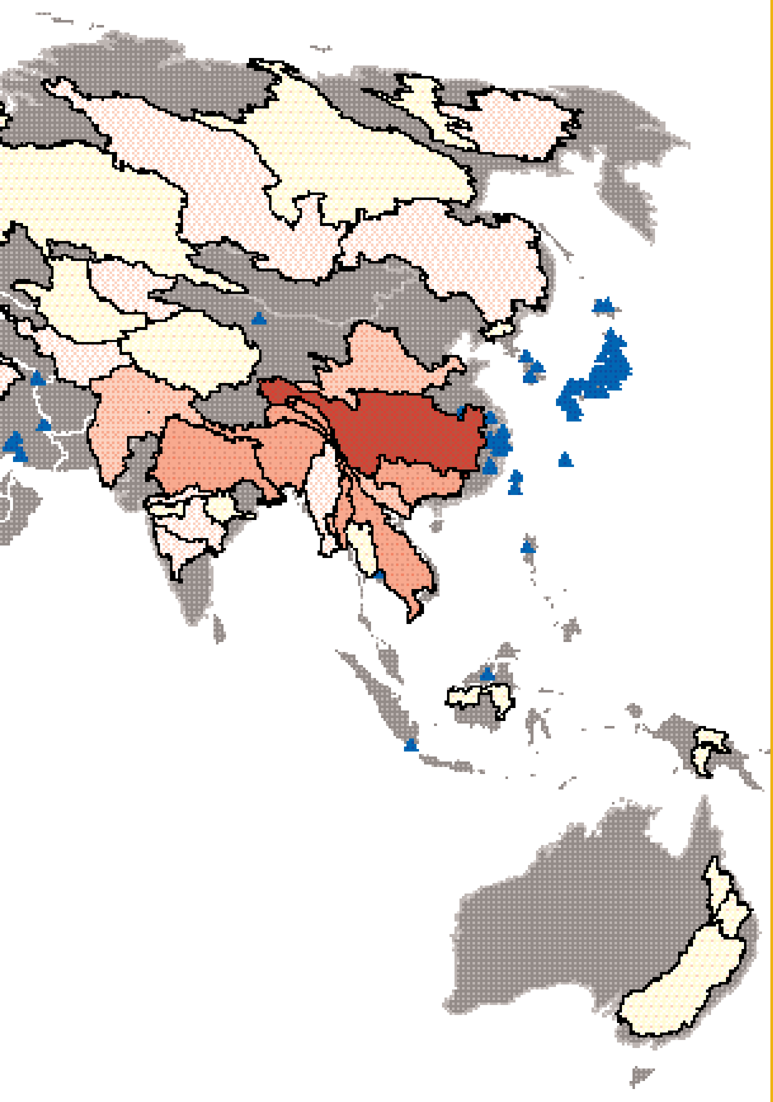
As water storage needs have been met and hydropower potential exploited dam construction in most developed countries has slowed down, with a few noticeable exceptions such as Spain and Japan. A few countries, like the United States, are even dismantling some dams in order to restore rivers. Meanwhile, in the developing world dams are usually one of the first actions by governments to increase the amount of water that can be used for irrigation and food production, electricity generation and drinking water supply. Whilst poverty reduction in the poorest countries is, as it should be, a priority, the potentially high social and environmental costs of dam development must be carefully considered before a project is approved.

The International Commission on Large Dams (ICOLD) has called for a doubling of the number of dams globally (Lecornu, 2002). But is it feasible to do this without

MAP 1



putting the basic ecological functions that sustain rivers at risk? How will the goods and services provided by freshwater ecosystems be affected, particularly downstream from new dams? Have enough lessons been learnt from mistakes in the past to avoid sites that cause major environmental and social impacts? Is the building of large dams realising untapped potential or is it putting rivers at risk, together with the livelihoods of poor rural communities?



Dam technology has improved over time. Today, a large dam can be developed in less environmentally damaging ways than in the past. Good site selection, such as avoiding building large dams on the main stem of a river system, and better dam design can significantly minimise impacts. Fish passes (where effective), the use of hydrological data (when available) to improve the replication of natural stream flow, and emphasis on appropriate temperature/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.

Efforts by the dam building industry to improve standards, such as the sustainability guidelines of the International Hydropower Association (IHA, 2003), are welcome. However, the sheer scale of some dam construction schemes, with numerous dams in river basins of high biodiversity value, makes the avoidance of major cumulative impacts virtually impossible, especially downstream and in deltas. Already some rivers, such as the Colorado, Rio Grande and Yellow River, do not reach the sea for part of the year and this is likely to get worse.

Map 1 shows the results of a global analysis of large dams (> 60 m high or with an installed capacity >100 MW) planned or under construction as of 2003 on a river basin scale. Data on dams is difficult to obtain, as there is no comprehensive and up-to-date database on both dams planned or under construction. The key data source for this analysis is the 2003 World Atlas published by the International Journal of Hydropower and Dams (IJHD, 2003). For more information on data collection see appendix 1. Globally, there are an estimated 1500 dams under construction and many more planned. However, on many of these no data is available and the analysis presented here, based on 551 of the largest dams, can only provide a partial picture. However, it serves to illustrate the threats to key river basins.

The analysis presented in *Map 1* and *Table 1* shows that the Yangtze River Basin in China has by far the highest number of new large dams planned or under construction – 46 new dams. The La Plata Basin in South America follows the Yangtze with 27, and the Tigris and Euphrates Basin in Turkey, Syria and Iraq with 26. The next three rivers, with 16, 15 and 14 large dams respectively are the Salween in China, Thailand and Myanmar, the Kizilirmak in Turkey, and the Ganges in China, Nepal, India and Bangladesh.

Table 1. River Basins with Highest Number of Large Dams Planned and Under Construction
(Includes dams >60 m and >100 MW)

Basin Name	Basin Size *('000 sq. km)*	Countries within Basin	Number of Large Dams	Types of Risk
Yangtze	1,722	China	46	Large basin under stress from population pressures. Loss of habitat threatens bird species as well as endangered Yangtze River dolphin
La Plata	2,880	Argentina, Bolivia, Brazil, Paraguay, and Uruguay	27	River basin with high biodiversity; threats to Pantanal and other internationally important wetlands
Tigris & Euphrates	766	Turkey, Iraq, Syria, Iran and Jordan	26	Arid basin; potential for conflicts over water withdrawal between Turkey and downstream countries
Salween	272	China, Myanmar, Thailand	16	Relatively pristine river with high biodiversity values
Kizilirmak	78	Turkey	15	Small heavily fragmented basin; Ramsar site located in Delta
Ganges	1,016	India, Nepal, China, Bangladesh	14	Endangered Ganges River dolphin; Sundarbans mangroves in delta
Tocantins	764	Brazil	12	Relatively developed river basin; further dam development and improved navigation will exacerbate degradation for use of farmland
Amazon	6,145	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	806	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	651	China, India, Bhutan, Bangladesh	11	High biodiversity in upstream areas; high population pressure in delta
Zhu Jiang (Pearl River)	409	China, Vietnam	10	Highly developed basin; some important sites for amphibians
Danube	801	Germany, Austria, Slovakia, Hungary, Croatia, Serbia & Montenegro, Romania, Bulgaria, Moldova, Ukraine	8	68 Ramsar listed sites as well as UNESCO biosphere reserve in delta
Hwang He (Yellow River)	945	China	8	River basin with severe water shortages; 4 endemic bird areas, 1 Ramsar site
Kura-Araks	205	Azerbaijan, Iran, Georgia, Armenia, Turkey	8	Biodiversity hotspot with 4 Ramsar sites, 1 Endemic Bird Area and 21 IBAs
Yesilirmak	36	Turkey	8	Delta designated as IBA
Büyük Menderes	25	Turkey	7	River delta protected as National Park, protected bird areas
Çoruh	19	Turkey	7	Fast flowing river with significant tourist industry based on rafting
Susurluk	22	Turkey	7	Highly developed basin. Delta is a candidate Ramsar site.
Ebro	83	Spain and Andorra	6	High economic importance of delta; important bird sites
Indus	1082	Afghanistan, Pakistan, India, and China	6	Endangered Indus River Dolphin; loss of mangroves and sea water intrusion in delta
Qezel Owzan	60	Iran	6	Endangered sturgeon species

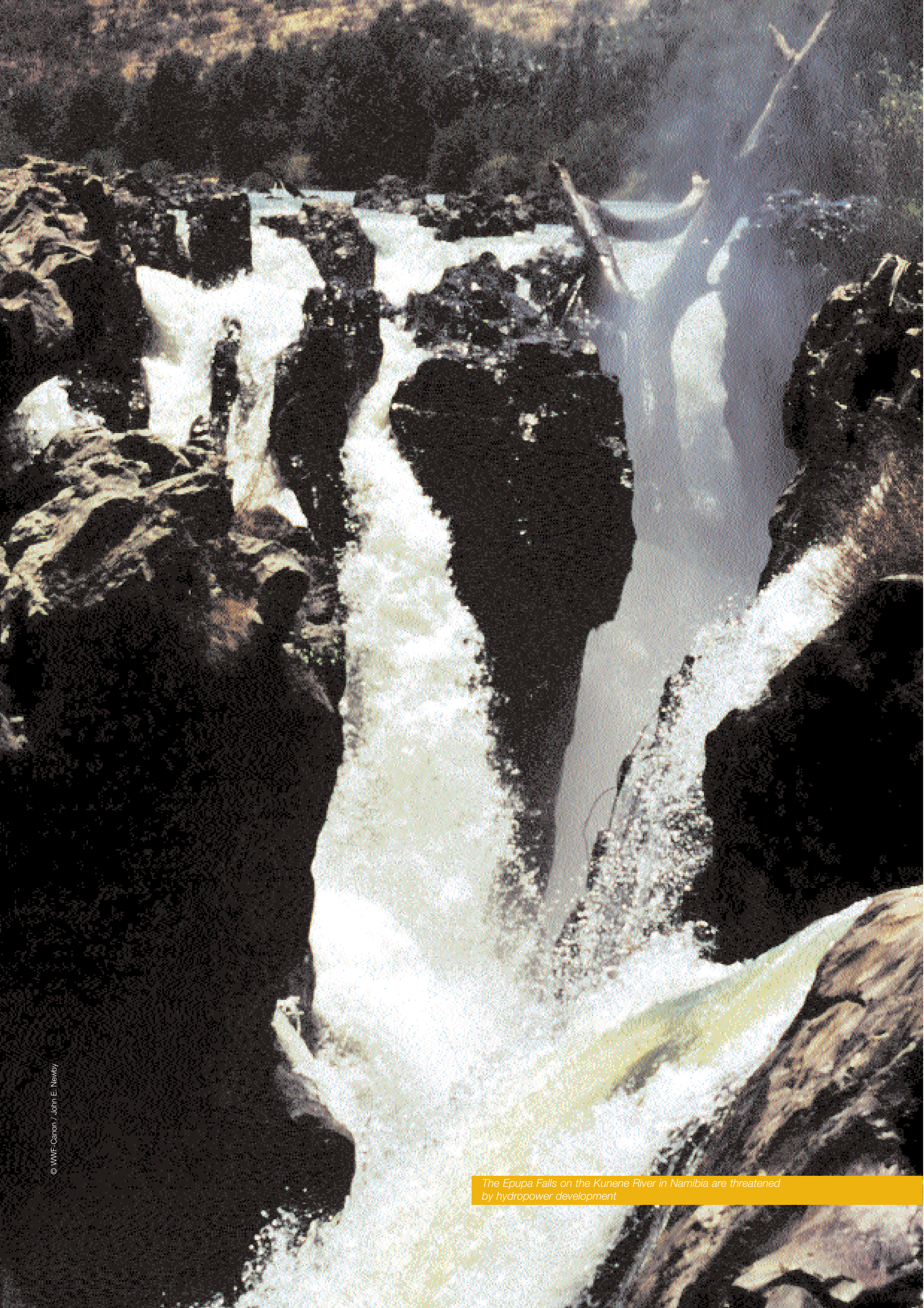
EBAs are avian centres of endemism defined by BirdLife International as sites where the ranges of endemic bird species overlap. IBAs, Important Bird Area, denote sites of international significance for the conservation of birds at the global, continental and sub-continental level (Birdlife International, 2003). A Ramsar site is an area designated as a wetland of international importance under the Convention on Wetlands signed in Ramsar, Iran in 1971.

The 21 top river basins highlighted here include all those basins that have 6 or more large dams planned or under construction as of 2003. In addition, there are 6 basins which have four or five large dams planned or under construction. These include the Orinoco and Magdalena basins in South America, the Sittong in Myanmar, the Red River in China and Vietnam, the Dez Karun in Iran and the Ceyhan in Turkey.

Additionally, there are river basins with two or three large dams planned or under construction, including the Nile in northeast Africa, the Acheloos and Axios-Vardar basins in Greece and the Balkans, the Göksu in Turkey, the Narmada in India and the Rio Colorado in Argentina. Finally, there are many basins with at least one large dam planned or under construction. The remaining dams are located in small coastal basins for which a basin boundary with sufficient detail was not available. These are represented in the global and regional maps as approximate point locations (blue triangles).

As the impacts of dams are site-specific, it is difficult to make clear assessments of the basin wide impacts without a detailed examination of each project, which was beyond the scope of this study. However, from the experience of existing dams, it is clear that the cumulative impacts of a succession of dams are a particular problem. These impacts are likely to be worse where there is a large number of new dams in a relatively small basin, in particular one that is relatively unaffected. In this light the plans for 16 dams in the Salween basin are of particular concern.

Dead trees in Itaipu Reservoir, Brazil & Paraguay.



The Epupa Falls on the Kunene River in Namibia are threatened by hydropower development

Regional Profiles:
Asia, Europe and South America

Results are also presented and analysed by geographic region in the following maps. *Map 2*, shows the analysis for Asia, *Map 3* shows the results for Europe (west of the Ural Mountains, including Turkey), and *Map 4* for South America. Africa is notable for the apparent low numbers of large dams planned or under construction; however, it is important to note that many countries do not report the dam locations to the IJHD, the key data source for the analysis. This does not imply that there are no dams planned or under construction, but may indicate a simple bias in the data. However, with the investment climate being worse in most of Africa than elsewhere, it is likely that fewer dams are being built due to the lack of capital.

The Mphanda Nkuwa Dam in Mozambique

The Mphanda Nkuwa project is planned on the lower Zambezi River in Mozambique, 64 km downstream from the Cahora Bassa Dam and has been proposed as an energy source for the Southern African Power Pool (SAPP), as well as to augment national supplies in Mozambique. The project involves a 101 m high, 457 m wide dam and will have an installed capacity of 1300 MW. The reservoir will inundate approximately 100 km2 and displace around 1400 people (UTIP website).

Despite a high dam and a large permanent reservoir, the dam is actually being promoted as a "Run of River" project, based on the fact that the daily outflows from the dam will remain the same and that there will be no seasonal fluctuations in river flow. By using the term "Run of River" the project proponents imply that the social and environmental impacts of Mphanda Nkuwa Dam will be minimal, but this is far from the truth. Besides the social and environmental implications of the 100 km^2 reservoir, such as displacement and flooded land, there will be serious environmental impacts because of daily fluctuations in water levels resulting from releases from the dam. But even more importantly, river flows will be affected through the relationship of Mphanda Nkuwa with the Cahora Bassa Dam upstream. The absence of environmental flow releases from the Cahora Bassa Dam after its completion in 1974 has seriously affected the biodiversity and productivity of the Zambezi Delta, with large reductions in fish and shrimp catches on the lower Zambezi. Cahora Bassa also stopped seasonal flooding of the floodplains, thus impacting on the livelihoods of downstream communities. These impacts are set to be exacerbated by the implementation of Mphanda Nkuwa, which is likely to result in even lower peak floods and higher base flows in the lower Zambezi.

This is likely to have further serious impacts downstream, in particular on fisheries production. In addition to environmental and social concerns there are economic considerations as well. The project will not address the basic energy needs of people in Mozambique in the short term. It is clearly a project with a power export orientation, designed to take advantage of the country's natural resources, with South Africa representing the best prospect for exports. New generating capacity is expected to be required for the South African system from 2010 onwards and available options for the provision of generating capacity for South Africa include new coal fired capacity, new combined cycle gas turbine plant capacity and increased imports from hydro electric capacity. Analysis shows that Mphanda Nkuwa is likely to be less economic than either coal or gas fired plant as a supply option for South Africa. However, under favourable assumptions the project has comparable economics and can not be totally discounted on economic grounds. But there is no guarantee though that these favourable assumptions will prevail. A low growth scenario in South Africa would present a risk, as would the fact that Mphanda Nkuwa's output will be dependant upon the flows in the Zambezi River, which have reduced significantly during drought years. Given the these risk factors, the Mphanda Nkuwa project would need to demonstrate real benefits relative to thermal generation options to make it attractive to a developer.

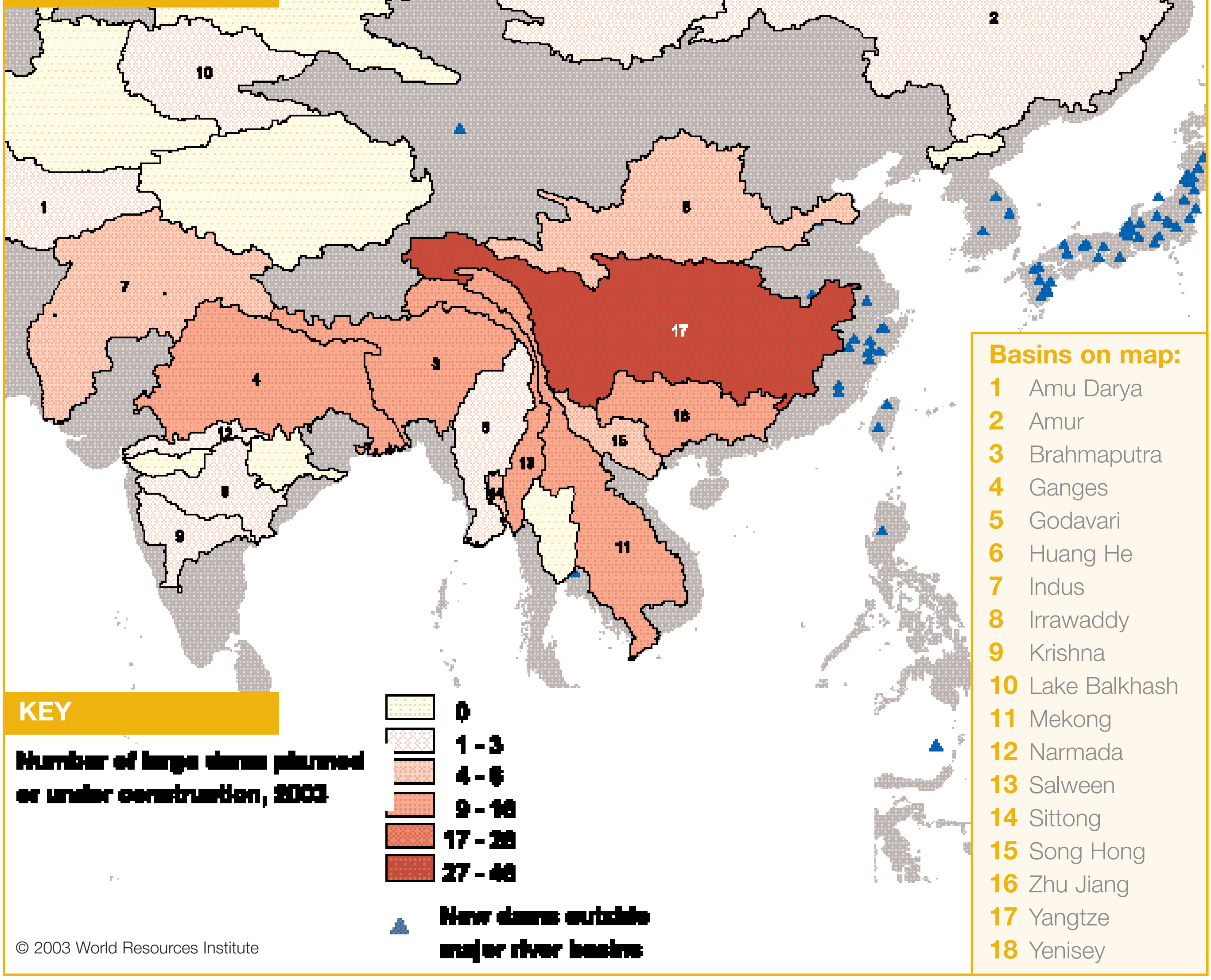
(Sources: Wilson, D (2004) and ITDG (in preparation)

Asia

Nine of Asia's river basins are among the 21 top rivers at risk from large dams. Many of these are entirely or partially in China where dam development and hydraulic works continue to have wide governmental support. China, the world's most populous nation, has a daunting task of maintaining a safe and sufficient water and electricity supply, particularly as the population continues to increase and its economy develops rapidly. The Yangtze Basin, with its 46 large dams planned or under construction poses the most concern. Presently, the basin is home to 400 million people, making it one of the most densely populated river basins anywhere on earth - with an average population of 214 people per km^2 (WRI et al., 2003). According to the Chinese government, dam development in the basin will provide electricity and support the country's economic development, while securing water supply for industrial and agricultural activities. Unfortunately this focus on economic development does not consider the long-term impacts on freshwater ecosystems and species. The Yangtze Basin is already highly fragmented by dams, with a significant number of dams over 15 m high within its catchment. The additional 46 dams planned and under construction will put further pressure on an already stressed basin.

Currently, the Yangtze is a rich centre for biodiversity, both terrestrial and freshwater. It has about 322 species of fish and 169 species of amphibians (WRI et al., 2003), including the Chinese sturgeon *(Acipenser sinensis)*,

MAP 2



which will be seriously affected by the new dams. Species at risk from further alteration of river and riparian habitats include the Chinese alligator *(alligator sinensis)*, the most threatened crocodile species in the world, which is only found in the lower reaches of the Yangtze River and its tributaries, and the finless porpoise *(Neophocaena phocaenoides)*, the only freshwater-adapted porpoise in the world, whose population is reported to be declining rapidly. The Yangtze River dolphin or baiji *(Lipotes vexillifer)*, which is the most threatened cetacean in the world, with only a few tens of individuals remaining, is also at risk. Both the Chinese alligator and the baiji are listed as critically endangered (IUCN, 2003). The historic distribution of the baiji included lower and middle reaches of the Yangtze River as well as some tributaries and lakes in the basin. The Three Gorges marked the upper limit of the baiji's distribution. By 1980 an estimated 400 individuals remained and by 1993 only 150 remained with their range substantially reduced (Ellis et al., 1993). Today, the few remaining individuals can be found just in the main stem of the Yangtze River (Reeves et al., 2000). The ongoing construction of the Three Gorges Dam and the multitude of dams on tributaries in the middle reaches of the basin will exacerbate the pressures on the remaining population of dolphins (Revenga and Kura, 2003). Freshwater cetaceans like dolphins are affected by dams as they need sufficient year round flow to move freely between deep pools and forage successfully (Reeves et al, 2003).

Another group of species that will be seriously affected by the dams are cranes. Cranes are among the world's most endangered families of birds, with nine species listed as threatened by IUCN (IUCN, 2003). The Siberian crane *(Grus leucogeranus)* is critically endangered, with the major threat being habitat loss, in particular the destruction and degradation of wetlands in its passage and wintering grounds. The rich mudflats of Poyang Lake in China constitute the major wintering site, holding 95% of the population. This seasonal lake depends on annual flooding from the Yangtze River. The Three Gorges Dam, which will change the hydrological regime of the lake, poses a major threat to this endangered species.

Fishing in Dongting lake in the Yangtze Basin.

The high diversity of fish species makes the Yangtze an important basin for fisheries. Populations of important commercial species, such as Chinese sturgeon, carp species and paddlefish *(Psephurus gladius)*, are all declining. The annual catch from the middle and lower Yangtze River used to average around 0.24 million tons, peaking at 0.44 million tons in 1954. After this time, catches show a general decline and in the period 1983-2000 the annual catch was down to 0.11 million tons (Chen et al., 2003).

The Salween River Basin is a transboundary river basin located in Myanmar and Thailand, with parts of the upper catchment in China, where it is called the Nu River or Nujiang. At present the Salween River Basin is one of the last rivers in Southeast Asia that is only lightly fragmented. Sixteen new dams could have a devastating environmental impact in this relatively small basin (272,000 km^2). The Salween River has high endemism with 47 out of 143 fish species being endemic (WRI et al., 2003), including *Hampala salweenensis and Hypsibarbus salweenensis* (WWF, 2001), with more species likely to be discovered as many areas remain unsurveyed. In addition to fish there is also a diverse turtle fauna with between 10 and 15 genera represented, many of which are riverine species (WWF, 2001). According to recent reports the Chinese government is now reviewing its development plans for the Nu River. Although there is as yet no final conclusion with respect to the Nu River dams (Interfax, 14-04-2004), WWF welcomes this development and urges a full assessment of cumulative impacts, as well as of alternative options.

In the upper basin the river runs parallel with the Mekong and Yangtze rivers, all flowing down from the Tibetan Plateau within less than 100 km of each other. This area, the Three Parallel Rivers Region, was designated a World Heritage Site by UNESCO. Because of the high elevation and deep gorges of the three rivers, the ecosystem in this region is extremely fragile, and once damaged, is likely to be almost impossible to restore. But because of this, the area has a high potential for hydropower as well. The Salween River Basin is also characterised by a high ethnic diversity and the construction of dams is likely to have significant social impacts.

The potential impacts on biodiversity from dam construction include, among other things, a decreased flow for the Salween River whilst the dams are filling up as well as changes to the seasonal flow patterns afterwards. This will result in stress on aquatic life downstream, with altered habitat, flow, hydrological regime and nutrients. As already witnessed in the Mekong (see below), a neighbouring river basin, mitigating measures during dam construction, such as fish ladders have not been specifically tailored to Southeast Asian fish migration. Unless effective fish pass designs are developed, it is likely that fish will not be able to reach spawning and feeding grounds as the dams will block them from carrying out seasonal fish migrations. In a river basin where fisheries are an important source of protein, reduced fish catches will undoubtedly impact on local livelihoods and may be particularly damaging to marginalised communities.

Plans for a major dam building programme on the Nu river in China are currently under review.

The Tasang Dam in Myanmar

Myanmar, formerly Burma, has a very large technical potential for hydropower development. It is estimated to be around 37,000 MW of which only about 390 MW has been developed (IJHD, 2003). The development of hydropower is a government priority and about 15 medium to large projects are in different stages of implementation. By far the largest scheme is the 228 m high Tasang Dam to be built on the Salween River. The project, which is expected to have a capacity of up to 3600 MW, will be built on the river's main stem and is heavily export-oriented. In 1997 the governments of Myanmar and Thailand signed a Memorandum of Understanding for the export of 1500 MW to Thailand by 2010. Tasang is also part of the wider negotiations for the Greater Mekong Subregion (GMS) Power Grid with a recommended 500 kV power line between Tasang and Thailand, so sales from the project might go even further afield. The economics of the GMS power grid are disputed by civil society in the region. The project has come under public scrutiny for many different reasons. A major concern so far has been the social impacts of the project, which will be built in an area of tension between ethnic groups and the government and which are well documented elsewhere. Despite the gravity of these social impacts, the environmental impacts of the project are equally serious and should not be overlooked. Environmental concerns are largely due to the uncertainties surrounding the impacts of the dam and reservoir. The Salween is the last river in the region without any dams on the main stem and is generally seen as an area with high biodiversity values, although there is little information available on the region's ecosystems. The WWF Global 200 study describes its conservation status as vulnerable (WWF, 2001). There is little doubt that the dam and the reservoir, estimated to stretch back over 200 km, will have the usual impacts associated with large dams, such as inundation of terrestrial ecosystems, fragmentation of fish habitats and disruption of sediment transports. But as yet there is no Environmental Impact Assessment that is needed to make a balanced decision. The WCD, in its strategic priority of sustaining rivers and livelihoods, emphasises the importance of a better baseline knowledge and understanding of ecosystems. In the case of Tasang, the understanding of the Salween River is simply missing. The dam should not have been approved without a clear assessment of the environmental impacts.

Other basins in Asia that need to be highlighted are the Ganges, the Mekong, the Brahmaputra and the Pearl River (Zhu Jiang).

The Ganges River Basin, which runs from the central Himalayas to the Bay of Bengal, is another heavily populated basin, with an average population density 401 person per km^2 (WRI et al., 2003). The population density increases downstream, particularly in Bangladesh, which is the most densely populated country in the world (Rashid et al., 1998). Steep torrential upper reaches and extensive, meandering lower courses characterise the course of the river. Virtually, all of the Nepal Himalayas are included in the catchment area and the basin occupies 25% of the land area of India. The cultural and social-economic value of the Ganges is enormous. The combination of dense population, high population growth and poverty all place additional strain on the natural resources of the Ganges Basin. The basin also has the richest freshwater fish fauna anywhere in India (WWF, 2003a), supporting over 140 fish species.

An important species at risk in this basin is the Ganges River dolphin *(Platanista gangetica)*, which is classified as endangered by IUCN (IUCN, 2003; Reeves et al., 2000). Historically this species was quite abundant and found in large groups throughout its range. Populations have severely declined since historical times, with an estimated 1800 individuals remaining today in the Ganges-Brahmaputra Basin and an annual mortality rate of 10% (Behera, 2003). The major threats to the Ganges dolphin are the high level of river fragmentation due to dams and canals, accidental collisions with ships and fishing gear, direct harvest for oil and traditional medicines, pollution, and overfishing of its food source (Sinha et al., 2000).

The Ganges shares the delta in Bangladesh with the Brahmaputra River, which has its source on the Tibetan plateau and flows down through China and the Northeast of India. The country of Bhutan, a key area for hydropower development, lies entirely within the Brahmaputra basin. The Brahmaputra shares many characteristics with the Ganges basin, including small populations of the endangered Ganges dolphin. With 25 new large dams planned or under construction in the Ganges and Brahmaputra basins, fisheries in Bangladesh are particularly at risk.

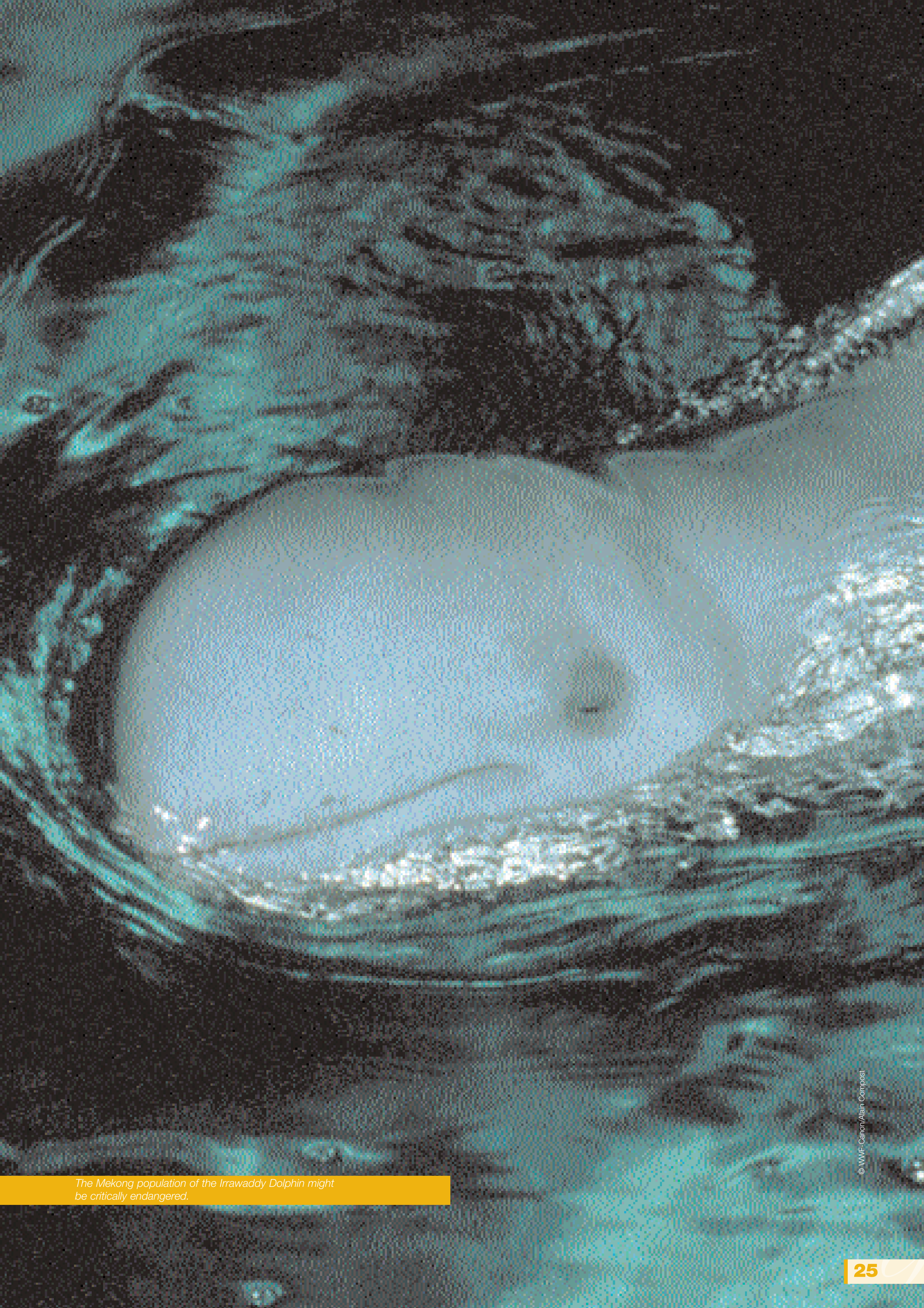
The Mekong is the largest river in Southeast Asia, with a total land area of around 795,000 km^2. Its headwaters are on the Tibetan Plateau in China, after which the river runs through Myanmar, Laos, Thailand, Cambodia, and Vietnam where it discharges into the South China Sea. The Lower Mekong Basin alone supports 60 million people from around 100 ethnic groups that live in and around the river; the great majority of them depending upon the river fisheries, particularly those of the Tonle Sap or Great Lake. According to the Mekong River Commission the commercial value of capture fishery in the lower Mekong Basin is estimated to be around $1.4billion annually (Mekong River Commission, 2004).

In terms of biodiversity, the Mekong supports numerous threatened and endemic fish species, including the giant Mekong catfish *(Pangasianodon gigas)*, the largest scale-less freshwater fish in the world (growing to over 300 kg). The basin is also home to one of three riverine populations of Irrawaddy dolphin *(Orcaella brevirostris)*, whose status is classed as data deficient, but the Mekong River population (which is now relatively well known) might be critically endangered. The Mekong also supports habitat for many other animals, including highly threatened species such as hairy-nosed otter *(Lutra sumatrana)*, Siamese crocodile *(Crocodylus siamensis)*, and big-headed turtle *(Platysternon megacephalum)*. Numerous birds rely on the river for breeding grounds and migration posts, including Sarus crane *(Grus antigone)* and giant ibis *(Pseudibis gigantea)*. The Tonle Sap has been declared a UNESCO Biosphere Reserve and it is believed to be the most productive inland water body in the world with respect to fisheries.

There are numerous large dams throughout the Mekong basin, some of which have had devastating effects on livelihoods, such as the Yali Dam in Vietnam. Water releases in 1999 and 2000 affected thousands through damage to crops and property in downstream Cambodia (CRES, 2001) and 5 people were reported to be killed. Another dam with well-documented negative environmental impacts is the Pak Mun Dam on the Mun River in Northeast Thailand. Of the 265 fish species recorded in the watershed before 1994, 77 species were migratory and 35 species were dependent on habitat associated with rapids. After the dam was built, the migratory and rapid dependent species were seriously affected as their migration route was blocked and many of the rapids disappeared. The fish catch upstream and downstream of the dam has reportedly declined by between 50 and 100% after the completion of the project, with some species completely disappearing from the catch. In particular, 51 fish species that were common before the dam was built are being caught “significantly less” and at least 50 rapid-dependent species have disappeared or declined (Amornsachai et al., 2000). The fish ladder that was part of the project proved to be ineffective, as many of the Mekong fish species were unable to climb it. In January 2003 the Thai government decided to open the gates of Pak Mun for four months every year and they were first opened in July 2003.

Four more large dams are under construction on the upper Mekong and tributaries in China and at least seven more large dams are planned, including Nam Theun II in Laos.

The Pearl River has ten dams under construction. It is the largest river in southern China, flowing to the South China Sea between Hong Kong and Macao. It is one of China's most important waterways and it is a highly developed basin, which is estimated to have lost 80% of its original forest cover (Revenga et al., 1998). The basin is densely populated with 194 people per km^2 (WRI et al., 2003). Along the Pearl River, over 3000 large and small dams have been built during the last 40 years and they have had the effect of obstructing migrations of Clupeidae fish (Arthington, 2002). Two species, Chinese gizzard shad *(Clupanodon thrissa)* and Reeve’s shad *(Tenualosa reevesii)*, have disappeared altogether from the regulated parts of the river, and major carp species (such as *Cirrhinus molitorella*) no longer sustain a viable fishery (Arthington, 2002). The basin is important for amphibians, with 127 species, as well as bird populations, with four endemic bird areas (EBA) and hosting migratory species which traverse the East Asian Australasian flyway (WRI et al., 2003).



The Mekong population of the Irrawaddy Dolphin might be critically endangered.

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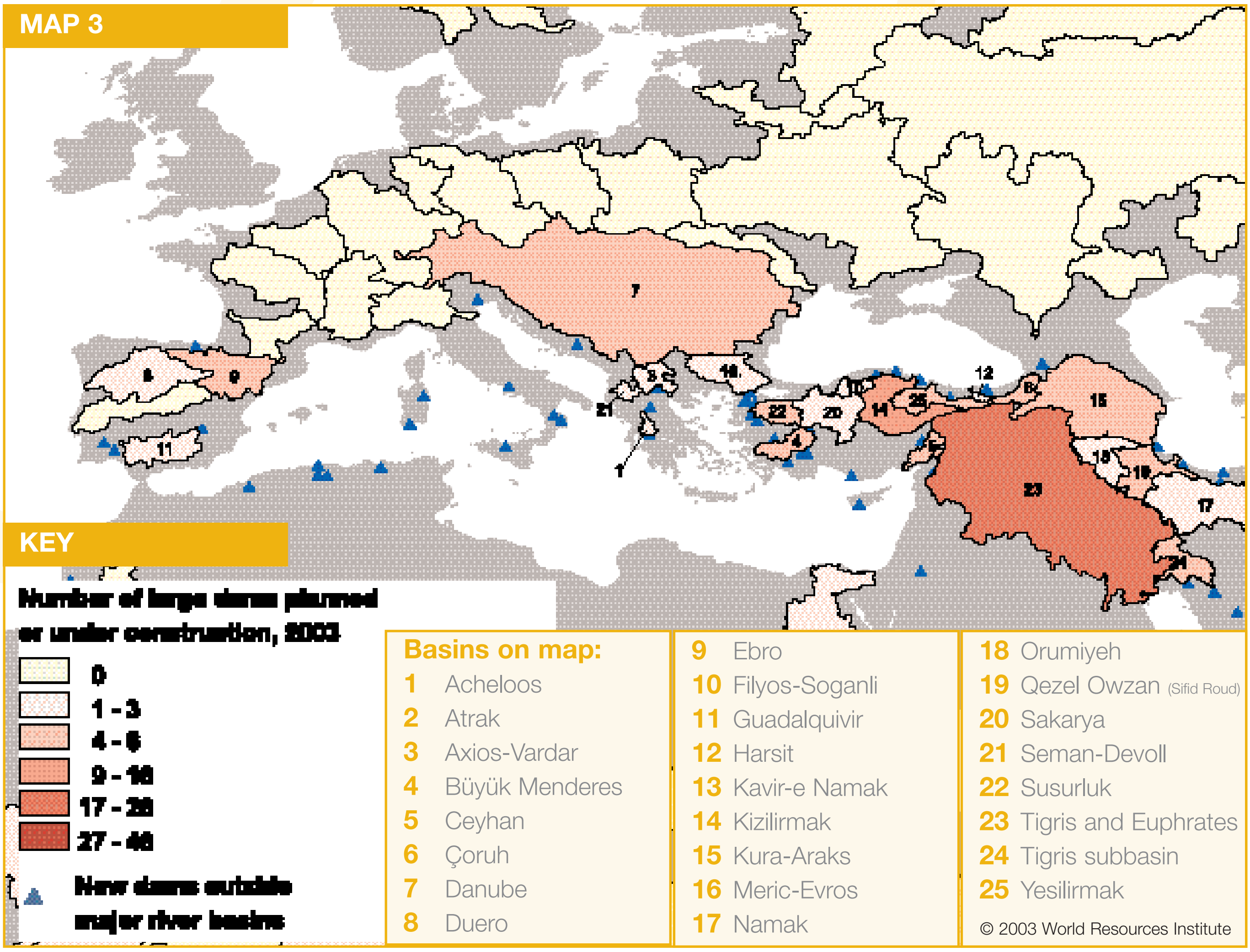
Europe & the Middle East

In Europe and the Middle East, the picture is similar. There are at least 20 basins with two or more dams planned or under construction in this region.

As Table 1 shows, the third river at risk from dam development in the world is the Tigris and Euphrates River Basin in Turkey, Iraq, Syria, Iran and Jordan. A semi-arid basin, the Tigris-Euphrates presents a very different, yet related set of problems to the Yangtze basin. This basin's vulnerability lies in its water scarcity and desertification risk with 99.2% of land falling into the dryland category of the United Nations Convention to Combat Desertification (UNCCD). 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 these major hydraulic works have resulted in changes in land-cover and land-use. This semi-arid basin is particularly vulnerable to degradation and this causes concern for the biologically rich wetlands that host a myriad of important species. 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 further altered. Water shortages in downstream countries are a distinct possibility.

From a biodiversity point of view the Mesopotamian marshlands in Iraq are a key habitat. The marshlands serve as spawning ground for a number of inland and brackish water species including the endemic giant catfish *(Silurus glantis and S. triostegus)*, the Hilsa shad *(Thenualosa ilisha)* and the pamphlet *(Pampus argenteus)* (FAO, 1990 as cited by UNEP, 2001). In addition, a major commercial species, the Penaeid



shrimp *(Metapenaeus affinis)*, depends on these marshlands as nursery grounds during its seasonal migration from the Arabian Gulf (Banister, 1994 as cited by UNEP, 2001). The marshlands also support significant populations of waterbirds. Two-thirds of west Asia's wintering waterfowl, estimated at several million, are believed to reside in the marshes of Al Hammar and Al Hawizeh. Incomplete ornithological surveys have reported 134 bird species in significant numbers from the area, of which at least 11 are globally threatened (UNEP, 2001).

The marshlands have suffered a dramatic decline since 1970 with a loss of around 93% of the original marsh area. Saddam Hussein's regime systematically drained the marshes for political reasons, although dam building and water diversions elsewhere have also played a role. It is estimated that up to 40% of Kuwait's shrimp catch originates from the marshes, and according to UNEP (2001) "the drying out of the marshlands is therefore likely to have had an important impact on coastal fisheries in the northern Gulf, with potentially serious economic consequences." Some of the water has begun to come back since the end of the Iraq war and efforts are underway to restore at least parts of the marshes but this could be severely hampered by new dam building upstream.

The Tigris and Euphrates basin also has 62 wetland-dependent Important Bird Areas (WRI et al., 2003). 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.

Another basin at risk in Europe is the Danube, a major transboundary river with ten riparian states and a total population of about 83 million. While this basin is fairly developed, with almost 70% of its land converted to agriculture, some important areas of forest and wetlands remain, including the Carpathian Mountains, the Lower Danube floodplains and islands, and the Danube Delta.

The upper reaches of the river have been heavily fragmented, but there are still valuable stretches of river

Dalmatian pelicans are threatened in the Kizilirmak Delta

Fisherman on Danube, Bulgaria.

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downstream. The Danube is one of Europe's richest rivers with regard to fish species, with 103 species reported (Revenga et al, 1998). Damming of the river has already limited fish migration and altered habitats. Of the five sturgeon species reported in the basin two have gone extinct. Other species at risk are the European eel *(Anguilla anguilla)*, three shad species, the Black Sea sprat *(Clupeonella cultriventris)*, and the critically endangered and endemic Asprete *(Romanichthys valsanicola)* (WWF, 2001).

The Danube basin is also one of the last European refuges for certain species of birds, like the white-tailed eagle *(Haliaeetus albicilla)* and black stork *(Ciconia nigra)*. Bird populations are at a fraction of their historical numbers (McAllister et al., 2001), and with the reduction of wetlands and floodplains from additional dams this trend may worsen.

The Itoiz Dam in Spain

Many of the high valleys of the Spanish Pyrenees have been dammed and further reservoirs are being built on the upper streams of the Ebro river basin. The 122 m high multi-purpose Itoiz Dam in Navarra Province in Northern Spain is nearing completion, despite years of massive popular resistance and several court judgements.

The dam was first proposed in 1984 and construction started in 1993. In October 1995 the Spanish National Administrative Court found that the Ministry of Public Works had not defined the objectives of the dam, which under Spanish law are supposed to be established before construction begins. Also, the project did not respect the 500 m limits around two Special Bird Protection Zones. In response, the provincial government in Navarra passed a new law in June 1996, changing the rules applicable to nature reserves. This effectively allowed the construction of the dam to continue, until in 1997 the Supreme court ruled that the amendment was unconstitutional and ordered the reduction of the reservoir volume from 418 million cubic metres to just 9 million. Nevertheless, construction on the dam continued and in March 2000 the Constitutional Court ruled that the provincial law amending the rules on conservation areas was constitutional.

In the meantime new engineering reports were published that indicated that the project had an extremely high risk of failure, and would never be permitted in any other EU country. The trial filling of the reservoir, set to start early in 2001, was subsequently delayed to allow for the drawing up of an emergency evacuation plan. Officials maintained that this was standard procedure and did not reflect safety issues. The filling of the dam received another setback when early in 2002 the Spanish Supreme Court rejected an appeal by the Navarra regional government, maintaining a maximum reservoir volume of 9 million cubic metres.

But very soon after this the tables turned again. Although the Spanish Supreme Court is technically the highest judicial authority, the Audiencia Nacional, a lower court, declared previous judgements legally unenforcable. The struggle against the Itoiz dam was finally lost early in 2004 when the European court of human rights, where environmentalists had taken the case, judged that the retroactive legislation by the Navarra regional government in 1996 altering the status of protected areas affected by the dam had not infringed local residents' human rights.

The Itoiz Dam is now completed and filling up. Despite nearly two decades of protest and countless court cases, in the eyes of the opponents of Itoiz, justice has not been done.

Two other basins to highlight in this region, with 15 and 8 dams planned or under construction respectively, are the Kizilirmak basin in central Turkey and the Kura-Araks in Georgia, Armenia and Azerbaijan. Both the Kizilirmak and the Kura-Araks contain important wetland areas for migratory birds. The Kizilirmak Delta, located in the central Black Sea region, is one of Turkey's most important wetland complexes and the only designated Ramsar site in the basin. More than 310 bird species, 75% of all known bird species in Turkey, use the delta for breeding, wintering, and migration (Özesmi, 1999). Several bird species in the delta are threatened, including the Dalmatian pelican *(Pelecanus crispus)*, the pygmy cormorant *(Phalacrocorax pygmeus)*, the red-breasted goose *(Branta ruficollis)*, the white-headed duck *(Oxyura leucocephala)*, the imperial eagle *(Aquila heliaca)*, the lesser kestrel *(Falco naumanni)* and the great bustard *(Otis tarda)* (Ramsar Data Base, 2003).

The WWF Water and Wetland Index Study (WWF, 2000) identified the Kizilirmak as having a good ecological status, even though fragmentation was already high. WWF's recommendations at the time were first to “prevent deterioration” and second to “prevent further fragmentation.” The Kizilirmak is now a River at Risk, with nine dams under construction and a further six planned. Meanwhile, the Göksu River, also in Turkey, is one of Europe's last few free flowing rivers. Now it has a second dam under construction on the Ermenek tributary and at least one dam planned on the main stem.

The Kura-Araks region has been identified by Conservation International and WWF as a globally important region for biodiversity conservation. It has several endemic genera and species of fish, mostly carps, loaches and bleaks. In addition it has four Ramsar sites, one Endemic Bird Area, and 21 wetland-dependent Important Bird Areas. Water flow in this river basin is affected by several dams, which have markedly changed the natural pattern of river hydrology. The effect on migratory fish has been a significant reduction in numbers (Bogutskaya, 2003). Given the adverse effects already experienced in the river basin, the eight large dams proposed or under construction make the Kura-Araks is a River at Risk.

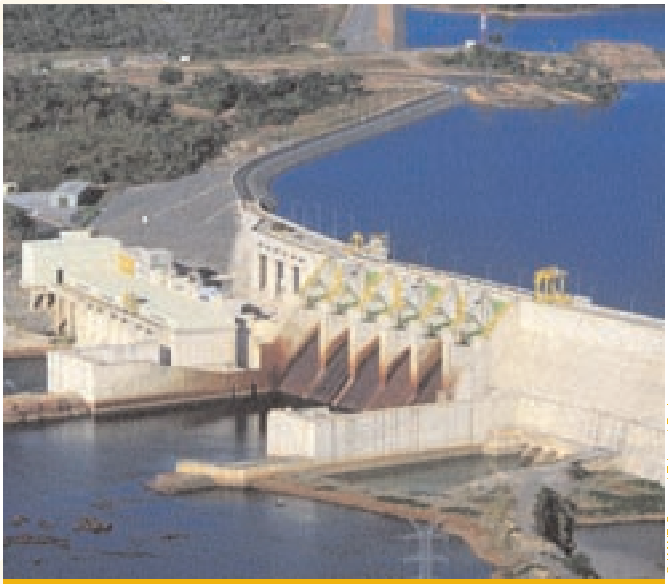
South America

South America is another region where dam construction is on the rise, both in already developed basins as well as in more pristine ones. The top river basin at risk from dam development in this region is the La Plata basin, with 27 dams planned or under construction, followed by the Tocantins basin with 12, the Amazon with 11, and the Orinoco and Magdalena basins with four large dams each.

The La Plata River Basin is the second largest in South America (after the Amazon) covering over 3 million km^2 (WRI et al., 2003) and is home to more than 110 million people. The basin is shared by Brazil, Bolivia, Paraguay, Uruguay, and Argentina, and has three major sub-basins: the Paraná, Uruguay and Paraguay. The Paraná River network flows from central and southern Brazil, through Paraguay and Argentina, to discharge into the Atlantic Ocean through the La Plata River, a coastal plain tidal river shared by Argentina and Uruguay. The river runs along the western border of the Atlantic forest region of Brazil, an area designated by Conservation International as one of the world's biodiversity hotspots. The basin is home to at least 355 fish species, six endemic bird areas, and 13 Ramsar sites (WRI et al., 2003).

The Paraná is the principal commercial artery in this region of South America, and navigation has been facilitated through dredging of the main river channel at different sections. It is already a strongly fragmented river, with many dams and hydraulic works. Some of these, such as Itaipu, are among the largest in the world and have affected the migration of numerous fish species (IDRC, 2003). 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.
However, this relatively unaffected state of the upper Paraguay could change with the proposed Hidrovía project, which includes the channelisation of nearly 3,500 kilometres of the Paraná and Paraguay rivers.

The Hidrovía could threaten the integrity of the Pantanal wetlands as well as the livelihoods of the indigenous communities that depend on the wetlands. According to experts lowering the level of the Paraguay by an average of only 25 cm, would reduce the flooded area of the Pantanal by 22% at low water (Gottgens, 2000) and probably create the potential for more frequent flooding downstream. If the Hidrovía goes ahead, it is possible that, with increased access, the upper Paraguay basin will become more susceptible to dam development, further threatening the integrity of the basin. Besides the Hidrovía, 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 km^2.



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The Cana Brava one is one of the first of a cascade of dams on the Tocantins River.

The Tocantins-Araguaia river system on the eastern border of the Amazon is likely to be the location for an extensive dam building programme. Already it holds a very large reservoir at the Tucurui Dam, and presently one dam is under construction with at least 11 more planned. As in the Paraná-Paraguay rivers, there are also plans for a Hidrovía to facilitate transport of soybeans down river. The basin is divided between the Amazonian ecoregions and the Cerrado savannah, and although biodiversity is not as high as in the Amazon, it is still important. The area around the Araguaia basin is part of the Xingu-Tocantins-Araguaia moist forests

Corpus Dam – Argentina and Paraguay

The Upper Paraná forms the borders between Paraguay and Brazil, and between Paraguay and Argentina, and development of hydropower on the river has been subject to many years of diplomatic negotiations. In 1973, Brazil and Paraguay signed the Paraná River Hydroelectric Use Treaty, which led to the construction of Itaipu Hydroelectric plant completed in 1982. In the same year Paraguay and Argentina signed a treaty on the development of Yacyretá Dam and six years later Brazil, Paraguay and Argentina signed a Three-Party Agreement, also referred to as the Itaipu–Corpus agreement, on the further development of the hydraulic potential in the Paraná. This agreement established the levels of the river and its permissible variations at the different hydroelectric developments in the watershed common to the three countries, and envisioned another large dam project at Corpus, midway between Itaipu and Yacyretá.

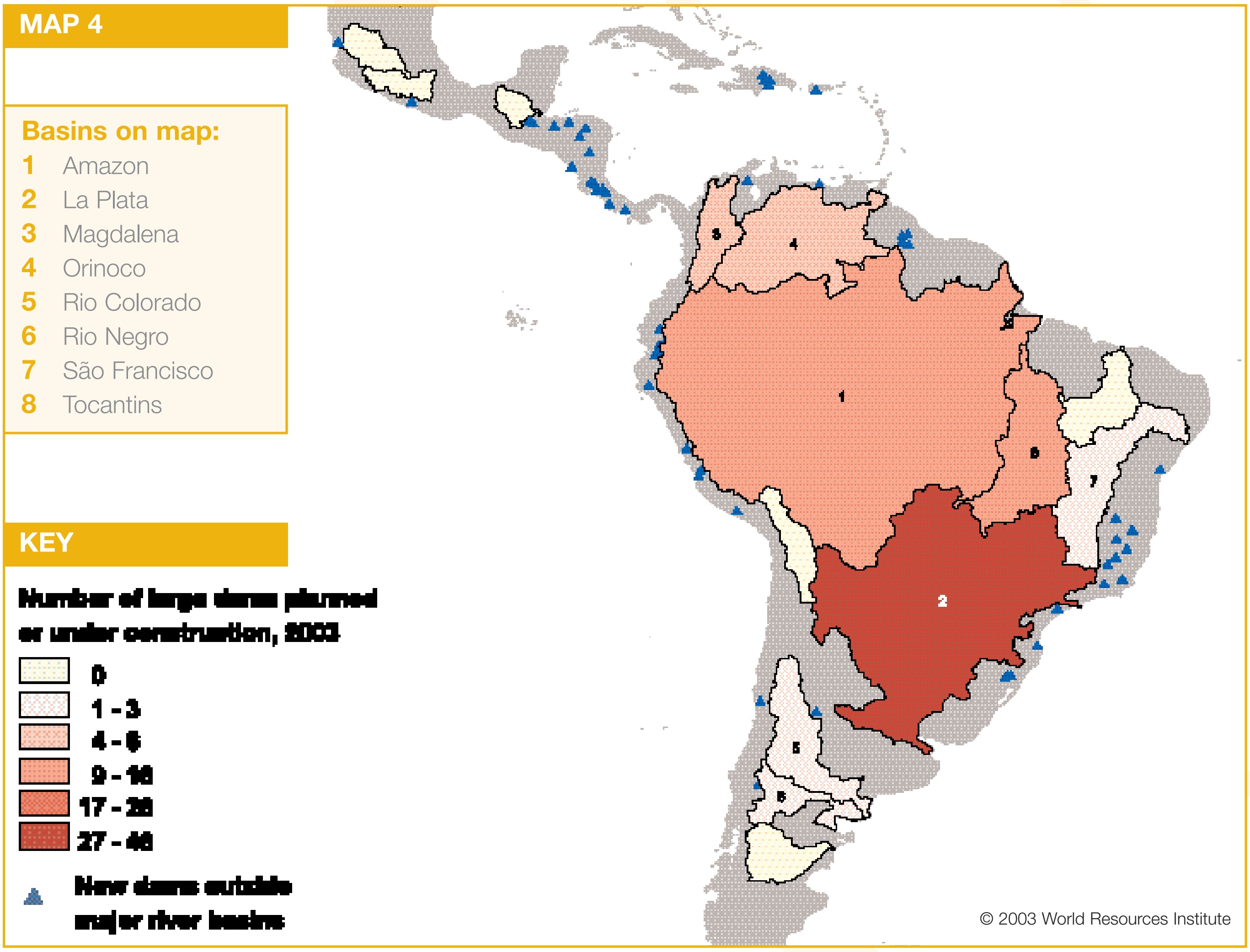
Despite years of preparations, the Corpus dam, which is comparable in size to Yacyretá, remained in the planning stage because of slow progress at Yacyretá. In May 2000, Argentina and Paraguay signed a working agreement, which calls for constructing the dam through international public bidding, and assures that the project's construction will be environmentally sound. More recently the governments of Paraguay and Argentina decided to carry out new studies on construction of the Corpus project, as well as to increase the level of the Yacyretá Reservoir. If the Corpus project finally goes ahead, this will destroy the last remaining free flowing stretch of the Upper Paraná, flood large amounts of land between the Itaipu and Yacyretá reservoirs, as well as many canyons and tributaries which have a high biodiversity value. It is estimated that Corpus will flood 380 km^2, 120 km^2 in Argentina and 260 km^2 in Paraguay.

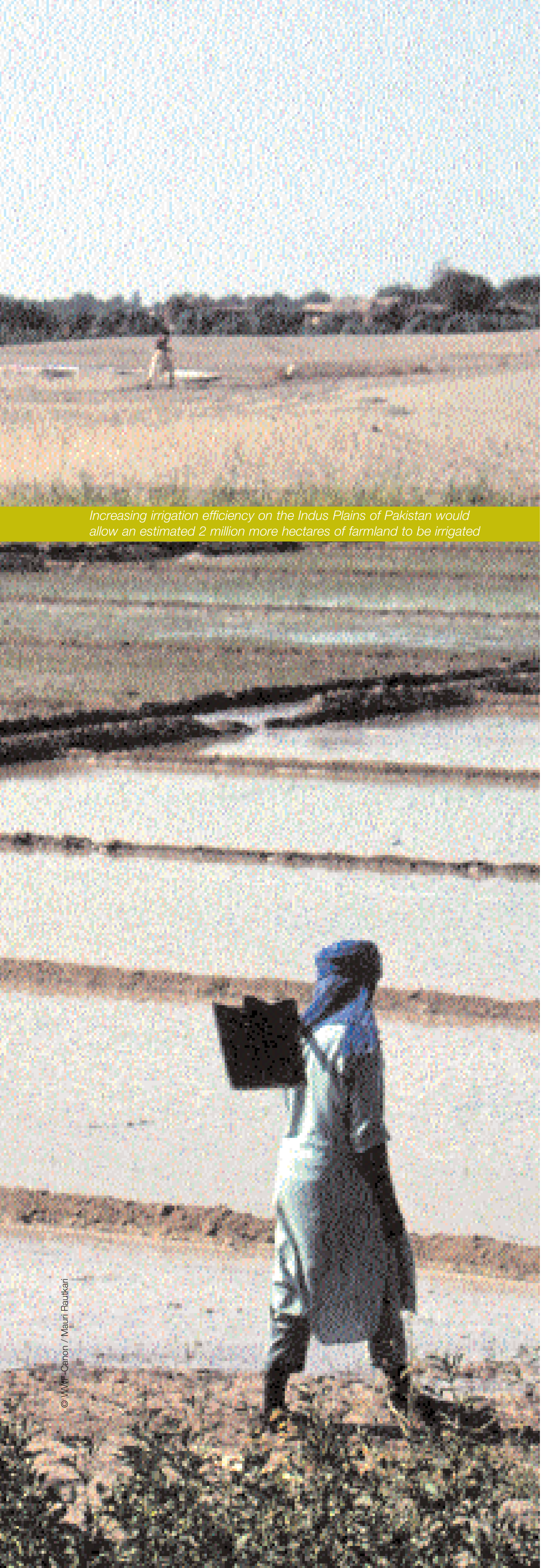
The Corpus project has met with large popular resistance, which is not surprising considering the experiences of local people with the Yacyretá dam. The WCD referred to Yacyretá as “a classic illustration of delayed and incomplete resettlement.” In 1996, a referendum was held about the Corpus Dam in Misiones province in Argentina, which was also affected by Yacyretá. An overwhelming majority of 88% voted against the Corpus dam, a decision that was meant to be binding. In this light, to progress with the project would be illegal, at least on the Argentine side.

terrestrial ecosystem, which has a particularly high diversity of bats (90 species) and birds (527 species) (WWF, 2001). Locally though, many species populations have become extinct, as the area is very accessible and much of the forest has been felled to make way for cattle ranches and agricultural fields. The construction activities associated with the dams and the Hidrovía will contribute to further degradation of both the terrestrial and freshwater ecosystems in this river basin.

The Amazon River, and the region as a whole, is one of the most important areas for biodiversity in the world. In terms of freshwater fish species, it is by far the richest with over 3000 fish species, of which 1800 are endemic (Revenga et al., 1998). Four of the eleven dams planned or under construction are in the middle to lower reaches of the Amazon affecting some key species that inhabit these areas. The lower reaches of the basin have specific species that are at risk from the impacts of existing dams and will be further vulnerable as new and large dams are constructed. Freshwater mammals are particularly vulnerable. The Amazon manatee *(Trichechus inunguis*), the only manatee that lives exclusively in freshwater, is found in the tributaries of the lower Amazon Basin and depends on the seasonal flooding of the river which is likely to be reduced by the dams. Another species at risk is the Amazon River dolphin *(Inia geoffrensis)*. This species is the largest of all river dolphins, the only South American cetacean species and considered vulnerable to extinction by IUCN (Nowak, 1991 and IUCN, 2003). Dams pose a major threat to these mammals. Important habitats that will most likely be affected include some of the ten Ramsar listed sites in the basin, which are located in coastal areas downstream from the large dams planned or under construction. The coastal mangrove system is specifically adapted to seasonal flooding and powerful tidal influences. It is an area exceptionally high in biodiversity including large populations of migratory birds and fish (WWF, 2001).

MAP 4





Increasing irrigation efficiency on the Indus Plains of Pakistan would allow an estimated 2 million more hectares of farmland to be irrigated

V. Dam Right – best practice case studies

As the analysis shows, a number of high value ecosystems are at risk from current and planned dam construction, in addition to the damage already caused by existing dams. Obviously, these dams will provide important functions in terms of water and electricity supply or flood control. The key question is how these services can be provided without undue environmental damage and species loss, as well as benefits for all, in particular for those people directly affected by dams. In some cases this is a matter of site selection and management, in others it will be through the development of alternative options. This section presents a number of best practice case studies which show the way forward, both for new and existing dams. They illustrate how recommendations made by the WCD can work in practice.

The WCD's main recommendations related to strategic priorities for decision-making include:

- Establishing clear public acceptance, including the provision of reliable information to enable stakeholders to make informed decisions and participate effectively in decision-making. With regard to indigenous people, this must include free, prior and informed consent.
- A comprehensive assessment of all the options ensuring in particular that social and environmental aspects are given equal weight alongside technical factors.
- A post-project review of existing dams from a technical, environmental and social point of view.
- The development of a basin-wide understanding of the aquatic ecosystem and of ways of maintaining it.
- The recognition that the benefits of dams should be widely shared.
- Checks and balances to ensure that at all stages and procedures comply with agreed standards.
- Special attention to transnational impacts.

Reducing wasteful water use

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 can waste as much as 80% of the water. Such waste is driven by misplaced subsidies and artificially low water prices, often unconnected to the amount of water used (WWF, 2003b). 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 m^3 per hectare of field crops this could avoid the construction of two dams with the capacity of Tarbela, Pakistan's largest dam.

In Spain, water for irrigation is one of the reasons behind the promotion of extensive water infrastructure under the Spanish National Hydrological Plan (SNHP). The plan involves the construction of 118 dams and the re-routing of 22 rivers to move water from the North to the South of Spain, mainly to meet the rapidly rising demand from agriculture and tourism. Flood irrigation is still the most common method in regions of Spain with a supposed 'structural water deficit'. In these regions the overall water use efficiency is a maximum of 55-60%. This obsolete irrigation method wastes enormous amounts of water in regions that have a supposed water scarcity. WWF and many other stakeholders have lobbied for years for the Spanish government to properly consider alternatives. Finally, a new Socialist Spanish Government, elected 14 March 2004, stated publicly that it will stop the 900 km Ebro transfer project and develop other means to solve the water problems in Spain, although it remains unclear if all major planned water infrastructure will now be adequately assessed.

Often there are alternatives to growing water intensive crops. According to a recent study by WWF (WWF, 2003b), rice, sugar, cotton and wheat are the 'thirstiest' water users in selected river basins of high importance for biodiversity. For example, in the Niger River Basin rice is grown in the dry season. A switch to wheat would enable a 20 to 40% reduction of water use, while still producing a crop of equivalent commercial and food value. In some cases, it may be more sensible to improve food supplies through imports and use limited water resources for purposes other than wasting the water on water intensive crops and building expensive dams. It is crucial that options assessments for dam projects consider these demand-side alternatives, rather than just looking at supply-side choices.

Another option is the re-use of urban wastewater. According to the Food and Agriculture Organization of the United Nations (FAO, 2003) the potential benefits of using this wastewater are enormous: a city with a population of 500,000 and a water consumption of 120litres/day/person produces about 48,000 m^3/day of waste-water. If this wastewater were treated and used in efficient irrigation, it could supply some 3,500 hectares. Water scarce Israel is a world leader in wastewater reuse and treated wastewater is an integral part of the water resources of the country. Almost 40% of water supply to agriculture is through wastewater (Shelef, 2001). This goes hand in hand with efficient drip irrigation systems which are used on 50% of agricultural land (Hinrichsen, 1997).

According to the WCD, increasing the effectiveness and sustainability of existing water, irrigation and energy systems should be given priority in the options assessment process. Globally, increasing efficiency does not negate the need for additional water supply but can substantially reduce the amount of additional storage needed.

Comprehensive options assessment for the Vistula River in Poland

Comprehensive options assessment is crucial to deciding appropriate development responses. Governments are clearly a key player in this process but in one case in Poland, where the government refused to carry out a proper assessment of alternatives, WWF decided to commission an independent assessment as a means of influencing the decision-making process. This assessment was directly inspired by the work of the WCD and followed the WCD strategic priorities for decision-making.

The proposed Nieszawa Dam site is on the Vistula River, with 1047 kilometre the longest river in Poland. For several hundred kilometres of its course, the Vistula has retained a semi-natural character and the dynamics of a free flowing river. Its valley is characterised by very high biodiversity and is an ecological corridor of international importance. Only one dam in Wloclawek obstructs the lower and middle course of the Vistula. This dam, operating since 1970, has caused a number of problems, in particular an increased threat of upstream flooding caused by ice jams at the Wloclawek Dam reservoir. Additionally, the stability of the dam is under threat from downstream riverbed erosion due to a lack of sediment transport since the dam was built.

In the 1990s water management authorities and local governments proposed a second dam near Nieszawa to secure the stability of the Wloclawek dam. The dam, which was also to include a hydropower plant, was approved by the Polish government and parliament. This resulted in protests by the Ramsar and Bern Convention secretariats, as well as from numerous Polish and international NGOs who considered the dam at odds with the sustainable development principle included in the Polish constitution and the European Union's Bird, Habitat and Water Framework Directives. As a EU accession country at the time, Poland was expected to comply with these directives.

WWF believed that no proper needs and options assessment had been carried out by the proponents of the Nieszawa Dam and 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.

Three options were considered in depth:

1. Construction of new dam at Nieszawa (cost 346 million Euro)
2. Safety and mitigation works at Wloclawek Dam (cost 83 million Euro)
3. Decommissioning of Wloclawek Dam (cost 48 million Euro)

This led to the following conclusions and results:

- 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.
- Modernisation of the Wloclawek Dam will only partly resolve the problems caused by impeded sediment transport and associated downstream erosion.
- The gradual decommissioning of the Wloclawek Dam and reduction in the level of the storage reservoir is the most sustainable option for solving these problems.

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

A recent publication by UNEP's Dams and Development Project (UNEP DDP, 2004) provides a number of other case studies of comprehensive options assessment. However, there are still many instances, such as in the case of the SNHP, where alternatives are not being considered properly and where development needs and objectives are not arrived at in an open and participatory process. The WCD provides detailed guidelines for comprehensive options assessment covering strategic and project level assessments as well as tools such as multi-criteria analysis and economic risk assessment. As yet, there is little evidence that these are being followed widely.

The Vistula River has retained the character of a free flowing river for parts of its course

Integrated River Basin Management

The WCD demonstrated the need for a comprehensive options assessment, as well as environmental and social assessment, emphasising the importance of a basin-wide understanding of ecosystem functions, values and requirements. This is best achieved through an Integrated River Basin Management (IRBM) approach which involves considering and balancing the social, environmental and economic factors within river basins and involving stakeholders in decision-making on development projects such as dams.

A more informed and concerted effort to strengthen the river basin organisation as an institutional structure is important in improving the planning and management of large dams in the context of their river basin. Indeed, river basin organisations such as the Mekong River Commission can have multiple benefits for stakeholders and their role should be considered in the context of future management of dams. As a coordinated entity with a clear mandate they can provide an objective, a-political, or even mediatory forum for dialogue where a wide array of stakeholder interests can be heard.

In the European Union (EU) river basin management is now a legal requirement under the Water Framework Directive (WFD). The WFD, which is legally binding on the 25 EU Member States, applies to all waters, surface (rivers, lakes and coastal waters) and groundwater, in a river basin. Its objective is the achievement of 'good ecological and chemical status' in all waters by 2015, as well as to prevent the deterioration of current status. Volume and variation of water flow are included in the definition of ecological status. This is of particular relevance to dams, which interrupt stream flow. Surface waters that are classified as 'heavily modified water bodies', including those already extensively dammed, should still be managed to achieve "good ecological potential" and "good chemical status". Under this Directive, EU Member States have to implement management plans for each river basin district, which in the case of international river basins requires cooperation between countries and the establishment of International river basin management plans.

The WFD does not stop new dams but puts strict conditions on all development of new water infrastructure. New projects are only allowed if they are shown to be of 'overriding public interest' and if there are no other options that are better in environmental terms. Other conditions are that the development must not compromise the achievement of the environmental objectives in other water bodies within the same river basin district or the objectives of other EU environmental standards, such as the Habitats Directive. Further, and in all cases, all practicable steps to mitigate adverse impacts must be taken. As far as existing dams are concerned, extensive mitigation measures may have to be applied for water bodies to reach "good ecological potential" and "good chemical status", particularly regarding minimum flow regimes, migration of aquatic fauna, sediment management and pollution reduction. The WFD is currently in the early stages of implementation and its real implications will only emerge with time. The aim is to find a balance between the environmental concerns and economic interests. Active participation of all stake-holders, including NGOs and local communities, in water management is an essential requirement of the Directive.

Stakeholder involvement in project assessment – Ta Trach Dam in Vietnam

For the people of Thua Thien-Hue Province in Central Vietnam, bad weather and floods are a regular occurrence but the floods of November 1999 were particularly severe. The damage in the province was unprecedented with around 400 people killed as well as many thousands of livestock. Several hundred thousand homes were flooded and the damage ran into millions of dollars. The central provinces of Vietnam are not only the most prone to natural disasters but are also amongst the poorest areas in the country, leaving a difficult dilemma on how best to prepare for the effects of extreme floods with only limited resources available. Structural works can play a role, but they may have undesired impacts elsewhere.

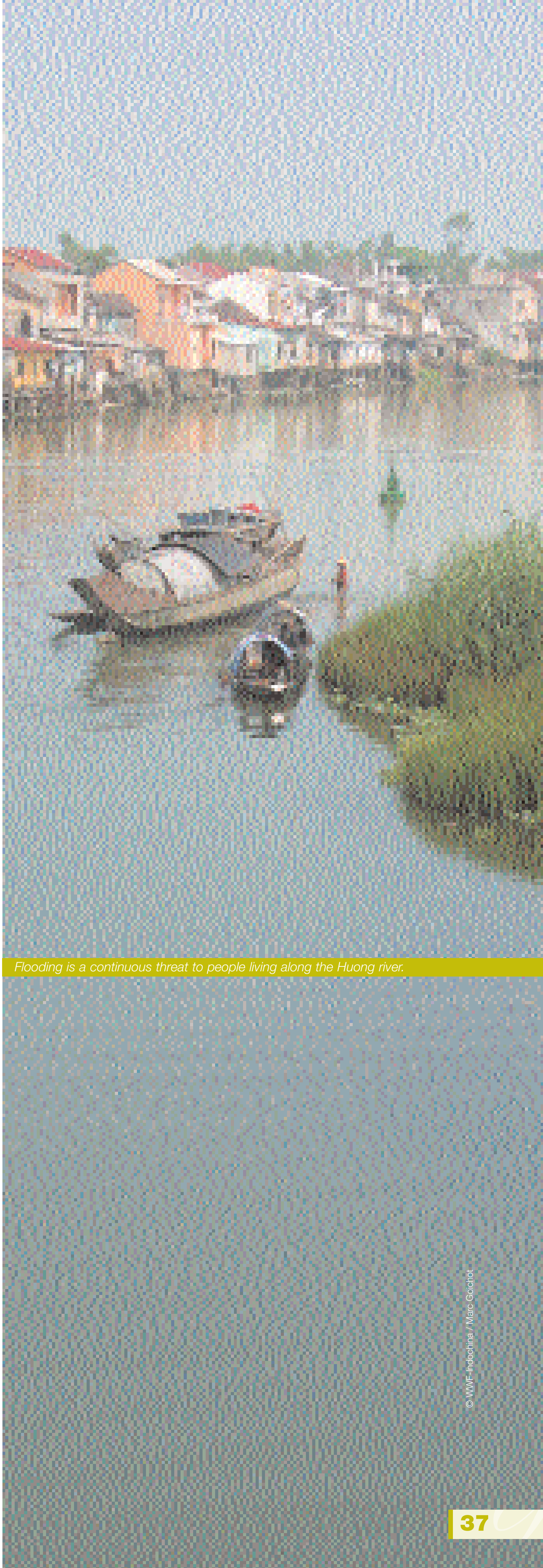
The Ta Trach Reservoir, planned on the southernmost branch of the Perfume (Huong) River, is one of the proposed measures for flood mitigation in this basin, potentially in combination with the Huu Trach Reservoir on another major tributary. Although flood mitigation is its major justification, the project, which involves a 56 m high dam, is also expected to supply water for agricultural, industrial and domestic consumption, generate electricity and help prevent salt intrusion into the lower section of the Huong River during the dry season.

WWF was invited by the potential project sponsor, the Japan Bank on International Cooperation (JBIC), to suggest viable measures for mitigating the effects of floods and options for improving the project design with regard to environmental and sustainability concerns. This step represented a concerted effort on the part of JBIC to follow the guidelines set down by the World Commission on Dams.

Despite concerns about the potential environmental impacts of the project, WWF decided not to oppose the dam, recognising that floods are a serious issue for Thua Thien-Hue province. However, this did not mean that WWF 'approved' of the project. Ideally, a much more comprehensive and historical data set should be available, enabling a more comprehensive analysis of both options and mitigation measures.

The WWF team, which included two independent experts, focused its recommendations on the need for non-structural measures as an integral part of the solution of the flood risks. These should include good warning and monitoring systems, appropriate management of sediment through the reservoir, control of building in the floodplain and data collection and monitoring of sea dynamics. A key recommendation is that another main tributary of the Huong River system, the Huu Trach River, is protected as compensation for environmental losses caused by construction of the Ta Trach reservoir. Protecting the Huu Trach River system and its watershed will help to maintain the large-scale ecological processes and migratory fish populations of the Huong River Basin as a whole. Protecting the watershed will also contribute to maintaining water quality in the Huong River, and creating a habitat corridor from the peaks of the Annamite Mountains to the coast, which is a key goal of the Green Corridor project that has recently commenced in Thua Thien-Hue province.

The decision on whether or not to fund the dam is now up to JBIC, but WWF will stay involved to make sure that the final JBIC proposal will be for a series of measures, both structural and non structural, and not just a dam. Also, WWF will lobby that as a trade off, the Huu Trach River will remain free of dams and that better management plans for this river will be developed.



Flooding is a continuous threat to people living along the Huong river.

Environmental flows for the Kafue Flats

Maximising the output of a dam, whether for hydropower generation or water supply, can have serious consequences both for ecosystems and other users, as inevitably flow conditions downstream of the dam are altered. However, it is often possible to adjust the operational regime of a dam to better meet a variety of needs, both in the case of existing and new dams. So-called 'environmental flows' provide critical contributions to river health, economic development and poverty alleviation (IUCN, 2003). 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. According to Postel (2003), 230 rivers worldwide now have some kind of flow restoration scheme in place. A well-known example is the Snowy River scheme in southeastern Australia where dams diverted 99% of stream flow from the river headwaters. In 2000 the Federal Government and the governments of Victoria and New South Wales signed an agreement which aims to restore the Snowy to 15% of its original flow in seven years, with an eventual target of 28% (Commonwealth of Australia, 2000).

Environmental flows are not just a 'luxury' for developed nations. South Africa's National Water Act 'reserves' an allocation of water to support ecosystem functions and in Cameroon flood restoration efforts are under way on the Logone River. In Zambia, WWF works on establishing an environmental flow regime in the Kafue River, where it runs through the Kafue Flats, as part of a wider project on integrated water resources management for the area. The project is a partnership with the Zambian Electricity Supply Company (ZESCO) and the Ministry of Energy and Water Development (MEWD). Many other stakeholders have been involved in project discussions.

The Kafue Flats are part of the Zambezi River Basin, covering an area of about 6500 km^2. The flats 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. It is estimated that about 700,000 people live in, or in the vicinity of, the Kafue Flats.

The area's natural water regime radically changed after the construction of two dams in 1969 and 1976. First, downstream from the wetlands, a hydropower plant was built in the Kafue Gorge. This installation supplies approximately 40% of Zambia's electricity needs. Because of the geography of the Kafue Flats a second dam was needed upstream to ensure a steady supply of river water and the Itezhi-tezhi storage dam was built 250 km upstream.

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. The number of Kafue lechwe, a type of antelope endemic to the Kafue Flats, decreased to a third of its original 1970 population of 100,000 and elephants, rhinoceroses, giraffes and wild dogs have disappeared from the area entirely. The decline has been exacerbated by increased poaching in the wetlands. Lower fishery yields and reduced availability of grazing land as a result of the altered flooding regime have also affected communities.

WWF is co-financing 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.

The Itezhi-tezhi Dam was built to ensure a steady supply of water for the Kafue Gorge power station, 250 km downstream

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Mitigation and green hydro certification

Where dams emerge as the best option for meeting water and energy needs negative environmental impacts can rarely be totally avoided, even when choosing the best sites. However, a range of mitigation measures can be applied to deal with the effects. While it is best to integrate mitigation measures into the design of new dams, they can also be applied retrospectively.

An independently certified approach to comprehensive mitigation of environmental effects can be found in the 'naturemade' green electricity label in Switzerland (*www.naturemade.ch*), which is supported by WWF, environmental and consumer associations and a number of electricity companies. This renewable energy label provides for the accreditation of new and existing hydropower plants and consumers can choose to buy 'green' electricity at a premium price.

To achieve the highest standard, 'naturemade star', hydro plants have to meet strict environmental conditions. These include environmental flows, sediment flushing, fish ladders and protective measures for wetland habitats. Additionally, operators have to pay a percentage of their income into a fund for environmental improvement measures, such as habitat restoration. The measures have to be additional to those that need to be taken to meet the certification criteria. Allocation of the fund is jointly decided by the plant operator, local authorities and environmental organisations. Fourteen Swiss electricity suppliers have gained certification under this label. Key to the credibility of this scheme is its independent status with board membership from industry, consumer and environmental organisations. In the United States, the Low Impact Hydropower Institute has a similar approach (*www.lowimpacthydro.org*).

Recommendations

The case studies demonstrate that a lot of progress can be achieved through the right policies and mindsets, whether it be on improving irrigation efficiency, options assessment or environmental flows. A strong legal framework in the host country is clearly important, but the case studies show that even without this good practice makes a lot of sense: environmentally, socially and economically.

Key recommendations highlighted in the case studies include:

- Give priority to increasing water and energy efficiency
- Undertake a comprehensive options assessment
- Involve stakeholders in project assessments
- Ensure a basin wide understanding of ecosystem functions
- Ensure implementation of effective mitigation measures, in particular environmental flows

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VI. Conclusions

Water scarcity is becoming critical in many parts of the world, with increasing pressure to build more large dams as the key solution. The global growth in electricity demand is also pushing the development of more hydropower dams. The analysis presented here highlights those basins and regions where large dams will most likely have wide reaching effects throughout the watershed, affecting natural habitats, species and human welfare. A new approach to decision-making in these river basins is essential to avoid large-scale damage.

One of the noticeable patterns in the distribution of new dams is that many of them are being built on much smaller river systems, often in coastal drainage basins rather than in major river systems. For example, Zhejiang province in the southeastern coast of China has seven new large dams under construction in its smaller river basins. Likewise, Turkey has about 25 new large dams scattered around its coastal provinces and basins. This is likely to have implications for coastal wetlands that are likely to receive less water both in total terms and in terms of seasonal flow.

Another interesting observation is that although larger river basins (size over 0.5 million km^2) dominate the top ranks of the rivers at risk, there is a significant number of much smaller basins (size less than 100,000 km^2) with more than 6 dams planned or under construction. For example, the Ebro basin in northern Spain and the Qezel Owzan in northwestern Iran have 6 large dams planned or under construction each, and the Büyük Menderes in southwestern Turkey has 7. In general, we can assume that large numbers of dams in small basins will have greater cumulative impacts than the same number of dams spread through a larger basin.

Looking across the basins, in terms of freshwater biodiversity impact, it is clear that some species are highly at risk. River dolphins and porpoises are among the most threatened mammals in the world and the 6 basins where these species live are all included among the top ‘at risk’ basins in this Rivers at Risk analysis. Four out of the 5 species of Asian freshwater cetacean are either critically endangered or endangered according to IUCN’s Red List of Threatened Species, These include the Yangtze River dolphin, the Yangtze River finless porpoise, the Indus River dolphin, and the Ganges River dolphin. The Yangtze, Ganges and Indus river basins are all among the top rivers at risk, with 46, 14 and 6 large dams planned or under construction respectively. The fifth species, the Irrawaddy River dolphin, is listed as data deficient. The species is found mainly in the Irrawaddy, the Mekong and the Mahakam (Kalimantan, Indonesia) river basins (Revenga and Kura, 2003). Both the Irrawaddy and the Mekong are among the rivers at risk from dam development according to this analysis. Finally, the single South American freshwater cetacean, 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 (for example 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, it needs to be remembered that the impacts of decline in fish populations extend into society. In many of the basins identified in this study freshwater fisheries have both a high commercial value and an importance as a food source for the poor that is often underestimated.

The analysis shows that certain countries have a larger concentration of dams under construction. For example, China and Turkey have predominantly more dams planned or under construction that any other country in the world. China has a total of 88 dams under construction and at least 36 more large dams planned; Turkey has 60 dams under construction and 50 more planned. China and Turkey, together with Iran and Japan account for 67% of the total number of dams under construction worldwide in 2003.

Concentrated dam building activity in the countries mentioned requires further consideration. None of these countries have implemented the recommendations of the WCD. The cumulative impacts of these dams in countries such as China and Turkey have not been adequately studied, 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. Concerning too is that as most large river systems have been dammed, additional large dams are being 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. There is an urgent need to apply an integrated river basin management approach to better balance social, economic and environmental factors. In our best practice case studies, we have presented examples from around the world on 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. 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.

References

Abell, R, Thieme, M, Dinerstein, E and D. Olson (2002) *A Sourcebook for Conducting Biological Assessments and Developing Biodiversity Visions for Ecoregion Conservation. Volume II: Freshwater Ecoregions*. World Wildlife Fund, Washington, DC, USA.

Abramovitz, J N (1996) *Imperiled Waters, Impoverished Future: The Decline of Freshwater Ecosystems.* Worldwatch Paper 128. Worldwatch Insititute, Washington, D.C., USA.

Adams, W M (1985) *The Downstream Impacts of Dam Construction: A Case Study from Nigeria.* In: Transactions of the Institute of British Geographers NS. Vol 10: 292-302.

Amornsakchai, S, Annez, P, Vongvisessomjai, S, Choowaew, S, Thailand Development Research Institute (TDRI), Kunurat, P, Nippanon, J, Schouten, R, Sripapatrprasite, P, Vaddhanaphuti, C, Vidthayanon, C, Wirojanagud, W and E Watana (2000) *Pak Mun Dam, Mekong River Basin, Thailand.* A WCD Case Study prepared as an input to the World Commission on Dams, Cape Town, available on-line at: *www.dams.org/kbase/studies/th/*

Arthington, A H (2002) *Environmental Flows: Ecological Importance, Methods and Adapting Australian Experience to the Mekong.* Ubon Ratchathani University, Ubon Ratchathani province, Thailand. Available on-line at: *www.terraper.org/ubon_dialogue/Angela_Arthington_paper_edited.htm*

Asian Development Bank (ADB) (1999) *China Resettlement Policy and Practice-Review and Recommendations*. Draft for Reviewing. Regional Technical Assistance Project, Manila, Asian Development Bank.

Banister, K, Backiel, T and J Bishop (1994) *The present state and likely future of the fishes of the Tigris-Euphrates Basin.* Unpublished report. Wetland Ecosystems Research Group, University of Exeter, UK

Behera, S K (2003) *Ganges river dolphin conservation project: Status report July 2003* WWF-India

BirdLife International 2003 *BirdLife's online World Bird Database: the site for bird conservation.* Version 2.0. Cambridge, UK: BirdLife International. Available: *www.birdlife.org*

Bogutskaya, N G (2003 – Draft) *Delineating and describing the freshwater ecoregions of the former USSR*. WWF Grant No. JF06. Zoological Institute, Russian Academy of Sciences, Russian Federation.

Chen, D, Duan, X, Liu, S and W Shi (2003) *Status and management of fishery resources of the Yangtze River* Large Rivers Symposium, Phnom Penh 2003. Available online at: *www.lars2.org/*

Clay, J (2004) *World Agriculture and the Environment,* Island Press, Washington.

Commonwealth of Australia (2000) *Heads of Agreement:* The Agreed Outcome from Snowy Water Inquiry. 6 December 2000. Available online at: www,isr.gov.au/library/content_library/HeadsofAgreement.pdf

CRES, Centre for Natural Resources and Environmental Studies (2001) *Study into impact of Yali falls dam on resettled and downstream communities* Vietnam National University

Dore & Xiaogang (2004) *Yunnan Hydropower Expansion:* Update on China's energy industry reforms and the Nu, Lancang and Jinsha hydropower dams. Working Paper from Chiang Mai University's Unit for Social and Environmental Research, and Green Watershed.

Dynesius, M and C Nilsson (1994) Fragmentation and Flow Regulation of River Systems in the Northern Third of the World. In: *Science 266: 753–762.*

Ellis, S, Leatherwood, S, Bruford, M, Zhou, K and U Seal (1993) Baiji *(Lipotes vexillifer)* population and habitat viability assessment. Preliminary report. In: *Species 20:25-28.*

FAO (1990) *Iraq: Assistance in Aquaculture development.* Report no. 12/90 TA-IRA 2. TCP/IRQ/ 8953 (F) as cited in UNEP (2001) The Mesopotamian Marshlands: Demise of an Ecosystem. Available online at: *www.grid.unep.ch/activities/sustainable/tigris/marshlands/ mesopotamia.pdf*

FAO (1995) *Effects of Riverine Inputs on Coastal Ecosystems and Fisheries Resources.* FAO Fisheries Technical Paper No. 349, Rome, Italy.

FAO (2003) *Improving irrigation technology* Available online online at: *www.fao.org/ag/magazine/0303sp3.htm*

Fearnside, P M (1999) *Social Impacts of Brazil's Tucuruí Dam* In: Environmental Management 24 (4): 483-495.

Gottgens, J (2000) *The Paraguay-Paraná Hidrovia: Large-scale Channelization or a "Tyranny of Small Decisions"* Available on-line at: *www.pantanal.org/gottgens.htm* **Viewed February 2004**

Hinrichsen, D, Robey, B, and U D Upadhyay (1997) *Solutions for a Water-Short World. Population Reports,* Series M, No. 14. Baltimore, Johns Hopkins School of Public Health, Population Information Program.

Horowitz, M, Salem-Murdock, M, Niasse, M, Magistro, J. Nuttal, C, Kane, O, Grimm, C and M Sella (1994) *Les Barages de la Controverse. Le Cas de Fleuve Senegal.* Paris, Harmattan.

IDRC- International Development and Research Center, Canada (2003) *Environment and Natural Resources Management Research Activities*. Available on-line at:
web.idrc.ca/en/ev-26522-201-1-DO_TOPIC.html
Viewed, December 2003.

IJHD International Journal of Hydropower and Dams (2003) *World Atlas and Industry Guide*

Interfax 14-04-2004 "No conclusion drawn" regarding dams on Nu River Online **Viewed 26 March 2004-04-28**
www.interfax.com/com?item=Chin&pg=0&id=5712684&req=

International Hydropower Association, Implementing Agreement on Hydropower Technologies and Programmes and Canadian Hydropower Association. (2000). *Hydropower and the World's Energy Future: The role of hydropower in bringing clean renewable energy to the world.* Available on-line at:
www.icold-cigb.org/Whitepaper.pdf

International Hydropower Association (2003) *Sustainability Guidelines*

ITDG (in preparation) *Impacts of the proposed Mphanda Nkuwa Dam in Mozambique* Report to WWF

IUCN (The World Conservation Union) (2002) *2002 IUCN Red List of Threatened Species.* Available on line at: *www.redlist.org*

Lecornu, J (2002) *VII Jornadas Españolas de Presas Zaragoza.* 29- 31 May 2002. Jaques Lecornu, ICOLD Secretary-General, Governor of the World Water Council.
Available online at: *www.icold-cigb.org/Zaragoza.PDF*

McAllister, D E, Craig, J F, Davidson, N, Delany, S and M Seddon (2001) *Biodiversity Impacts of Large Dams* Background Paper Nr. 1. Prepared for IUCN/UNEP/WCD.

Mekong River Commission (2004) "The land and its resources" viewed 9 June 2004. www.mrcmekong/about_mekong/land_resource.htm

Nowak, R M (1991) *Walker's Mammals of the World 5th ed.* Volume I and II. The Johns Hopkins University Press, Baltimore Maryland, USA.

Odinetz-Collart, O (1987) *La pêche crevettière de Mactobrachium amazonicum (Palaemonidae) dans le Bas-Tocantins, après la fermeture du barrage de Tucuruí (Brésil).*
In: Revue d'Hydrobiologie Tropical 20(2) 131-144

Özesmi, U (1999) *Environmental History of The Kizilirmak Delta, Turkey: Past and Present Resource Use and Conservation efforts. Conservation Strategies for Sustainable Resource use in the Kizilirmak Delta, Turkey.*

Postel, S and B Richter (2003)
Rivers for life: Managing water for people and nature Island Press

Ramsar Data Base (2003) Available online at:
www.wetlands.org/RDB/Ramsar_Dir/Turkey/tr006D02.pdf
Viewed, December 2003.

Rashid, H and B Kabir (1998) *Case Study: Bangladesh, Water Resources and Population Pressures in the Ganges River Basin* In: Alex de Serbinin and Vicroria Dompka (eds.). Water and Population Dynamics: Case Studies and Policy Implications. Available online at:
www.aaas.org/international/ehn/waterpop/bang.htm
Viewed December 2003.

Reeves, R, Smith, B and T Kasuya (eds.) (2000) *Biology and Conservation of Freshwater Cetaceans in Asia.*
IUCN Species Survival Commission Occasional Paper No. 23, Gland, Switzerland and Cambridge, U.K.

Reeves, R, Smith, B, Crespo, E and G Notarbartolo di Sciara (compilers) (2003) *Dolphins, Whales and Porpoises: 2002–2010 Conservation Action Plan for the World's Cetaceans*. IUCN/SSC Cetacean Specialist Group. IUCN, Switzerland and Cambridge, UK.

Revenga, C, Murray, S, Abramovitz, J and A Hammond (1998) *Watersheds of the World: Ecological Value and Vulnerability* World Resources Institute and Worldwatch Institute, Washington D.C., USA.

Revenga, C, Brunner, J, Henninger, N, Kassem, K and R Payne (2000) *Pilot Analysis of Global Ecosystems: Freshwater Systems.* World Resources Institute, Washington, DC, USA.

Revenga, C and Y Kura (2003) *Status and Trends of Biodiversity of Inland Water Ecosystems*. Secretariat of the Convention on Biological Diversity. Technical Series No. 11, Montreal, Canada.

Shelef, G (2001) *Waste water treatment, reclamation and reuse in Israel* In: Efficient use of limited water resources: making Israel a model state. Available online at:
www.biu.ac.il/SOC/besa/waterarticle3.html

Sinha, R K, Smith, B D, Sharma, G, Prasad, K, Choudhury, B, Sapkota, K, Sharma, R K and S K Behera (2000) *Status and distribution of the Ganges Susu, Platanista gangetica, in the Ganges River System of India and Nepa*l In: Biology and Conservation of Freshwater Cetaceans in Asia, R Reeves, B D Smith & T Kasuya (eds). IUCN Species Survival Commission Occasional Paper No. 23, Gland, Switzerland and Cambridge, U.K.

UN (2003) *Water for People, Water for Life: the United Nations Water Development Report.*

UNEP (2001) *The Mesopotamian Marshlands: Demise of an Ecosystem*

UNEP (2003) Desk Study on the Environment in Iraq. Available online at: *postconflict.unep.ch/publications/Iraq_DS.pdf*

UNEP DDP (2004) *Comprehensive options assessment of dams and their alternatives – Case studies*

UTIP (no date) *www.utip.org.mz*

Vörösmarty, C J, Sharma, K P, Fekete, B M, Copeland, A H, Holden, J, Marble, J and J A Lough (1997) The Storage and Aging of Continental Runoff in Large Reservoir Systems of the World. In: Ambio 26(4): 210–219.

Wilson, D (2004) *Economic viability of The Proposed Mphanda Nkuwa Dam Mozambique* Unpublished report to ITDG

World Commission on Dams (WCD) (2000) *Dams and Development: A new Framework for Decision-making.* The Report of the World Commission on Dams. WCD, Cape Town, South Africa.

World Commission on the Social Dimension of Globalization (2004) *A Fair Globalization: Creating Opportunities for All* Available online on: *www.ilo.org/public/english/wcsdg/index.htm*

WRI, IUCN, IWMI and R C Bureau (2003) *Watersheds of the World_CD.* WRI and IUCN-The World Conservation Union, Washington DC, Gland, Switzerland and Cambridge, UK.

WWF (2000) *Water and Wetland Index Study*

WWF (2001) *Global 200 Ecoregion Profiles.* Available online at: *www.panda.org/about_wwf/where_we_work/ecoregions/global200/pages/list.htm#water* **Viewed, November 2003.**

WWF (2003a) *Managing Rivers Wisely: Ganges Case study.* Available online at : *www.panda.org/downloads/freshwater/mrwgangacasestudy.pdf*

WWF (2003b) *Thirsty Crops- Our food and clothes: eating up nature and wearing out the environment*

WWF China (2001) *The unacceptable cost of the proposed south-north water transfer scheme in china – Summary*

Acronyms

ADB	Asian Development Bank
DDP	Dams and Development Project
EBA	Endemic Bird Area
EU	European Union
FAO	Food and Agriculture Organisation
IBA	Important Bird Area
ICOLD	International Commission on Large Dams
IHA	International Hydropower Association
IJHD	International Journal of Hydropower and Dams
IRBM	Integrated River Basin Management
IUCN	
JBIC	Japan Bank for International Cooperation
MDBC	Murray Darling Basin Commission
MRC	Mekong River Commission
NGO	
OMVS	Organisation pour la Mise en Valeur du Fleuve Sénégal
SAPP	Southern African Power Pool
SNHP	Spanish National Hydrological Plan
UNCCD	United Nations Convention to Combat Desertification
UNEP	United Nations Environment Programme
UNESCO	United Nations Educational, Scientific and Cultural Organisation
WCD	World Commission on Dams
WFD	Water Framework Directive
WRI	World Resources Institute
WSSD	World Summit on Sustainable Development
ZESCO	Zambian Electricity Supply Company

Appendix 1: Data collection

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*". The data in this table is limited to country, name of the dam and river, the type of dam and its height and purpose. A list of dams included in this analysis is available at: *www.panda.org/freshwater/dams*

Data on planned dams however, is far more difficult to obtain. To ensure consistency we have chosen, with one exception, to limit ourselves to dams on which information is available in the IJHD or related publications. Also, to keep in line with data on dams under construction, we have only included dams over 60 m high, or where information on height wasn't available dams with an installed capacity of more than 100 MW, with the exception of Latin America and Turkey (see below).

One of the implications of this is that the data set of this analysis is largely consistent, but there may be discrepancies with other figures published on river basins. For example, according to this analysis the number of large dams (>60m) in the Ebro Basin is six, but other sources use the term 'major dam' as including dams over 20m high. Where information on height was not available, dams with an istalled capacity of more than 100 MW have been included, with exception of the Latin America and Turkey (see below).

Information on planned dams has come from one of the following sources:

- 2003 World Atlas & Industry Guide – Country profiles
- News items in International Journal of Hydropower and Dams Issues 1 – 6, 2003
- Paper map - Dams in Latin America, published by IJHD 2000. This map is a graphic presentation of planned dams and dams under construction. Dams included are either over 60 m high or have a capacity of more than 50 MW.
- Paper map – Dams in China, published by IJHD 2000 This map includes dams under construction over 60 m high, and dams under design over 100 m high.
- Paper map – Dams in Turkey, Issued by IJHD 1999. No data is available on height or capacity so it is possible that some planned dams will be lower than 60 m or have less capacity than 100 MW

Additional data on height and capacity was derived from numerous Internet sources, varying from government departments, commercial Websites, bidding and tender sites or NGO sites, but no dams were added to the list based on NGO information alone.

The exception to this are the Chinese proposals on the Salween dams – these were verified by WWF China and data was derived from Dore & Xiaogang (2004).
The collected data present a number of difficulties and limitations.

Some dams included may not fit the criteria of being > 60 m or > 100 MW; this is particularly the case for dams derived from the Latin America and Turkey paper maps, and so for example, the number of dams in the Amazon may be overrated. On the other hand, it is quite possible that dams with a capacity of 50 MW are more than 60 m high. In this case there is no certainty and the dams remain included in the analysis.

A further problem is the accuracy of data. For example, the Turkish General Directorate of State Hydraulic Works (DSI) gives completion dates as far back as 2000 and 2001, for dams that are still listed as 'under construction' in the 2003 Atlas. Even information within the same website may be contradictory: construction on the Kigi Dam started in 1998 and is listed in one part of the DSI as being 168 m high and completed in 2003, whilst elsewhere on the same site the same dam is 146 m high and still under construction. The 2003 Atlas Country profile gives a completion date for this dam as 2008. The question of when exactly a dam is completed is relevant and without a clear answer. In some cases completed may mean the completion of the dam structure, in others the time when the first turbines come on stream or the time when the reservoir is fully impounded. There is no clear distinction of this in available data.

Finally it should be noted that data published by IJHD is not necessarily complete, and many more dams may be under development.

This report was prepared in cooperation with the World Resources Institute
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The full ‘Rivers at Risk’ report can be downloaded from:
www.panda.org/dams

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