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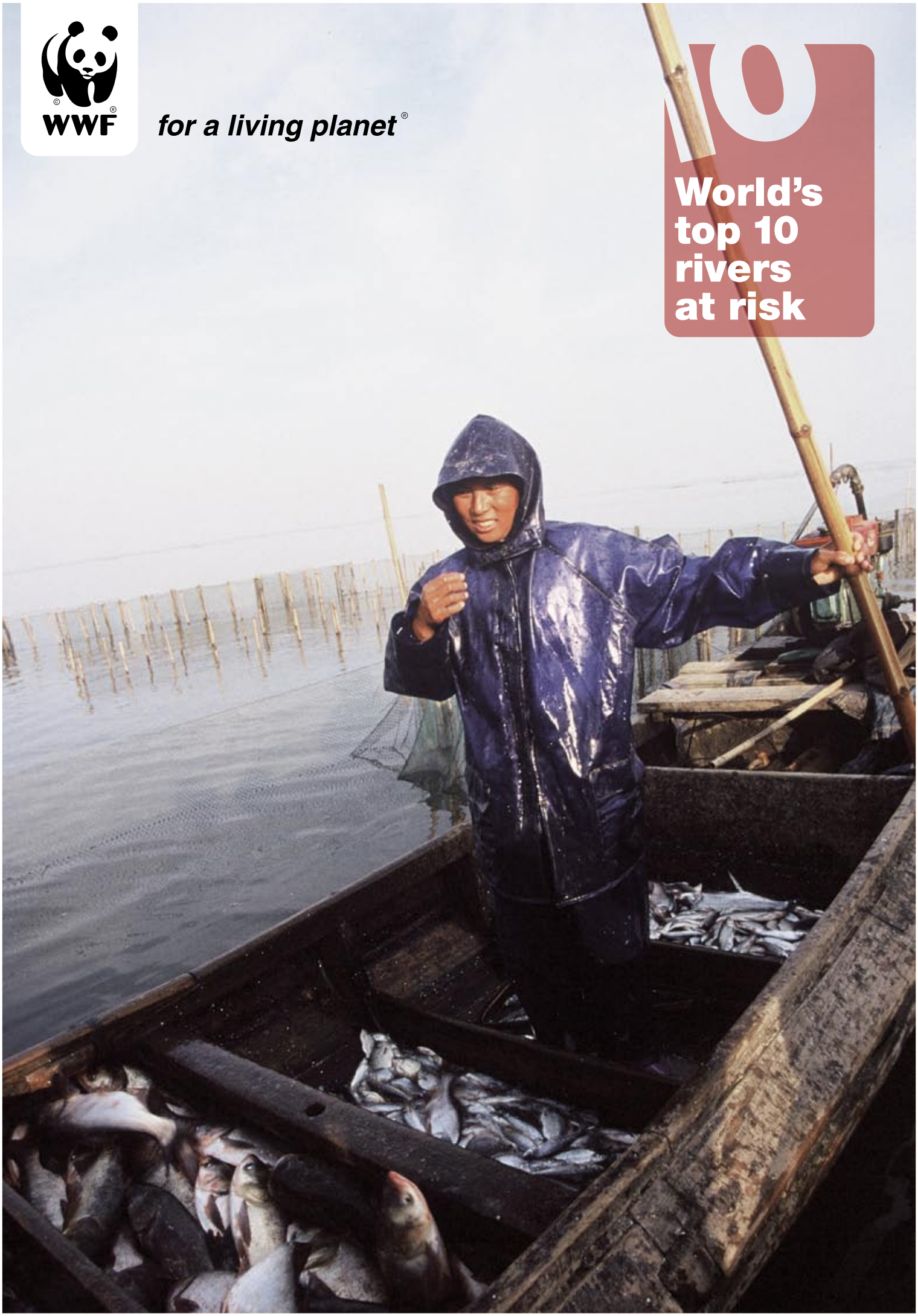
World's top 10 rivers at risk



World's top 10 rivers at risk

Wong, CM, Williams, CE, Pittock, J, Collier, U and P Schelle. March 2007.
World's top 10 rivers at risk. WWF International. Gland, Switzerland.
This report was designed by The Clarion Portfolio.

Cover image: Fisherman on Zhangdu Lake, the project area of the
WWF HSBC Yangtze Programme, Hubei Province, China.

Executive Summary

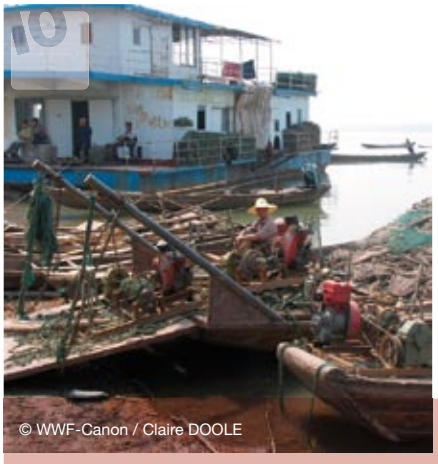
"What makes a river so restful to people is that it doesn't have any doubt - it is sure to get where it is going, and it doesn't want to go anywhere else."

Hal Boyle
Pulitzer prize-winning columnist

Perhaps there was a time when that was true, but no longer. Even the greatest of the world's rivers can no longer be assured of reaching the sea unhindered. These days the Rio Grande/Rio Bravo River, on the border of the U.S. and Mexico, often fails to reach the Gulf of Mexico, its strength sapped by dams and irrigation works diverting water to farmers' fields and city water supplies. The Indus, the Nile, the Murray-Darling, the Colorado, these are but a few of the once mighty rivers that now struggle to touch the ocean.

In fact, water extraction is only one of the daunting challenges that a river faces as it makes its way to its terminus. Dams and channelization destroy habitats, cut rivers off from their floodplains, and alter the natural ebb and flow on which a river's plants and animals depend. Invasive species crowd rivers' banks, drive out their native fishes, and choke their courses. Pollution fouls their waters, sometimes turning life-giving rivers into threats to human health. And climate change threatens to alter all the rules that rivers have lived by for thousands of years.

Why is this important? Because endangered rivers threaten the livelihoods of people. Rivers basins are the way nature gathers and delivers water for human use. These ecosystems provide electricity generation, transport, recreation and tourism, and valuable but often unaccounted flood and drought regulation, sediment and nutrient retention, and habitat for diverse fauna and flora. Freshwater biodiversity is an important source of food, income, and livelihood, particularly to rural communities in developing countries. Studies have estimated the economic value of river basins in the billions of dollars (Schuyt 2005).



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Houseboat at the banks of a heavily polluted Yangtze River, near Three Gorges Dam. Hubei Province, China.

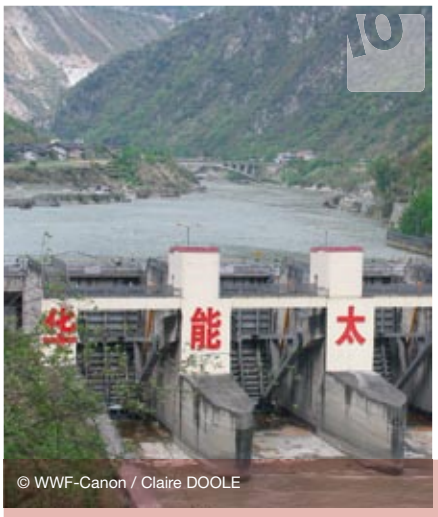
The primary objective of this report is to illustrate the most menacing threats to the world's great river basins, in order to encourage dialogue, provoke debate, and urge governments and other stakeholders to take action before it is too late. To do this, WWF has selected the "top ten" major rivers that, in our view, either a) already suffer most grievously under the weight of these threats or b) are bracing for the heaviest impacts. Thus, there are some rivers on the list that are so damaged that without serious restoration efforts they could be lost, and others that are relatively intact, but face massive degradation unless action is taken now to conserve them.

Surveying the results of eight international assessments, such as the Millennium Assessment 'Wetlands and Water' Synthesis Report that compiles the work of more than 2,000 authors and reviewers, WWF assessed the six most important threats based on their known impact on roughly 225 river basins. These are dams and infrastructure, excessive water extraction, climate change, invasive species, over-fishing, and pollution.

We provide this overview of the most serious threats to river basins to highlight those globally important watersheds at greatest risk, and to stress the importance of integrated river basin management solutions. Focusing analysis on watersheds with high ecological importance and those affecting large human populations, with a view to continental representation, the ten most endangered rivers emerge as: the Salween, La Plata, Danube, Rio Grande, Ganges, Murray-Darling, Indus, Nile, Yangtze and Mekong.

Summary of Threats

River basin	Corresponding Threat
Salween - Nu	Infrastructure - Dams
Danube	Infrastructure - Navigation
La Plata	Infrastructure - Dams and Navigation
Rio Grande - Rio Bravo	Water Over-extraction
Ganges	Water Over-extraction
Indus	Climate Change
Nile-Lake Victoria	Climate Change
Murray-Darling	Invasive Species
Mekong - Lancang	Over-fishing
Yangtze	Pollution



China Energy hydropower station Taipingyi, damming the Min River. Sichuan Province, China.

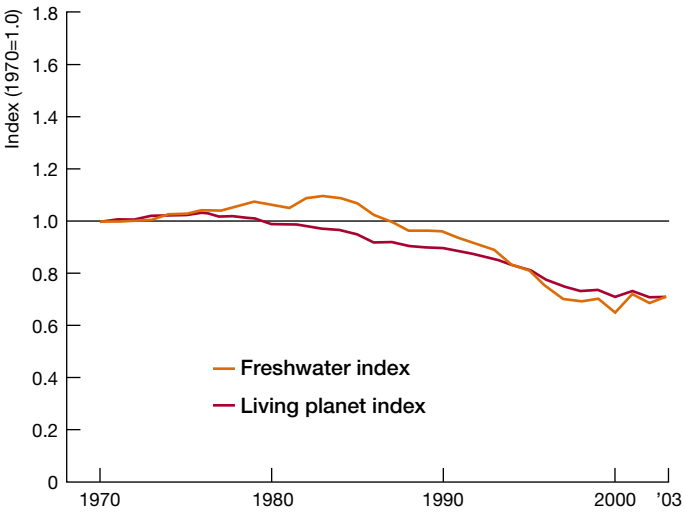
Introduction

Human civilization was born on a river bank. For thousands of years, the relationship was a relatively benign one. However, in the last 50 years, we have altered ecosystems more rapidly and extensively than in any other period in history (Millennium Ecosystem Assessment (MA) 2005). Rapid population growth, economic development and industrialization have led to the unprecedented transformation of freshwater ecosystems and consequent biodiversity loss (Convention on Biological Diversity (CBD) 2005; MA 2005). Today, 41% of the world's population lives in river basins under water stress (CBD 2005).

Freshwater ecosystems are the rivers, streams, lakes, ponds, groundwater, cave water, springs, floodplains, and wetlands (bogs, marshes, and swamps) that provide water for drinking, sanitation, agriculture, transport, electricity generation and recreation (CBD 2005; MA 2005a). They provide valuable but often unaccounted for flood, drought, nutrient and sediment regulation (CBD2005; MA 2005a). Freshwater systems are also habitat for diverse fauna and flora which provide an important source of food and fiber that sustain incomes and livelihoods, particularly for rural communities in developing countries (CBD2005; MA 2005a).

The threats to freshwater ecosystems are immense. More than 20% of the world's 10,000 freshwater species have become extinct, threatened or endangered in recent decades (CBD2005). Freshwater environments tend to have the highest proportion of species threatened with extinction (MA 2005). Now, the use of capture fisheries and freshwater is well beyond levels that can be sustained at current, much less future demands (MA 2005). Physical alteration, habitat loss and degradation, water extraction, over-exploitation, pollution and the introduction of invasive species threaten the planet's freshwater ecosystems and their associated biological resources (MA 2005; CBD 2005). Although there is increasing concern for the maintenance of freshwater biodiversity and the goods and services it provides, the demand for water itself is rapidly increasing as well (United Nations Educational Scientific and Cultural Organization (UNESCO) 2003, CBD 2005). Thus there is an ever increasing need and urgency for improved management of freshwater ecosystems.

Freshwater living planet index, 1970-2003



WWF's Living Planet Index 2004 graph shows decline in freshwater species' populations

Our review is not an exhaustive description of all threats to freshwater systems, nor, in light of insufficient data, does it provide a fully quantitative analysis to mount a purely objective case for the most threatened rivers. Instead, it captures the diverse social, hydrological, climatic and biological factors which threaten the integrity of major watersheds. Drawing from published literature and field expertise, this report offers WWF's view in 2007 of the most severe threats to the world's rivers, and based on this information, our judgment on the top ten endangered rivers.

We asked three questions: **a) what are the key pressures on and drivers of change in freshwater ecosystems, b) what are the most illustrative examples of these threats, and c) what recommendations or solutions can we pose to address these threats?**

In answering the first question, we summarized the findings of eight wide-ranging and authoritative global assessments[1] and identified the threats mentioned with the greatest frequency. The six threats that stood out are: water infrastructure (including dams), over-extraction of water, climate change, invasive species, over-fishing and pollution.

[1] CBD 2001; CBD 2003; Loh et al. 1998; Loh (ed) 2000; Loh (ed) 2002; MA 2005a; MA 2005b; Oki et al. 2004; Postel & Richter 2003; Vorosmarty et al. 2004; UN 2002; WWF 2005j.

Presently, 41% of the world's population lives in river basins under water stress (CBD 2005).

In answering the second question, we looked for ten river basins which best illustrate these threats. We focused on permanent rivers in primary watersheds, as defined in the "Watersheds of the World" publication (Revenga *et al*. 1998). We selected watersheds which:

1) Are in or contain regions of high ecological importance, as identified in WWF's Global 200 ecoregion analysis, based on the literature on freshwater fish species richness and endemism, endangered charismatic species, and migratory bird areas.
2) Face a high degree of threat from (and are depended on by) large human populations.
3) Provide continental representation, and depict the nuances of these threats to ecosystems.

We considered threats to biodiversity and services which intact ecosystems provide to people according to the Millennium Ecosystem Assessment, using the links provided by Alcamo *et al.* 2003, Duraiappah 2002, and Daily 1997. We selected rivers suffering from existing threats and those which are relatively intact but under imminent danger from emerging threats. It is important to note that most river basins suffer from multiple threats (for example, almost all river basins are threatened or will be threatened by over-extraction) that often compound each other, but in this report we concentrate on ten basins which are the best example of each threat.

Finally, we suggest some key solutions for better management in these basins. We end by summarizing the six threats and the ten basins representing these threats, and provide take-home recommendations under the framework of integrated river basin management.

Lock gates at Gabcikovo Dam on the Danube River, Slovakia.

1 Infrastructure

The Salween (Asia), the Danube (Europe) and the La Plata (South America)

Old ship wreck and fishermen on the Danube at Giurgiu, Romania.

The Salween faces heavy threat from damming, the Danube from navigation infrastructure, and La Plata from both.

Globally, free-flowing rivers, particularly those moving over a distance of more than 1,000 Km are increasingly rare. Only 21 (12%) of the world's 177 longest rivers run freely from source to sea, and the Salween is the last large free-flowing river in SE Asia (Goichot 2006). We know that free-flowing rivers provide water purification, sediment flux transportation and deposition, coastal and coral reef support, and cultural and aesthetic services which benefit people (Syvitsky, Vorosmarty, Kettner and Green 2005 in Goichot 2006; WWF 2006). Still, our understanding of nutrient and sediment services from free-flowing rivers over long distances and the contributions they make to the global ecosystem is limited. Free flowing rivers have immense value scientifically and are a phenomenon that we are on the brink of losing without fully understanding (Goichot 2006).

Though often hailed as a key to economic growth, particularly in the developing world, the benefits that dams provide, such as hydropower, often do not exceed the negative social and environmental impacts. Dams frequently transport their benefits, such as electricity, income and water, out of the basin[2] (Nilsson *et al.* 2005) and have displaced an estimated 40-80 million people worldwide (WCD 2000). Dam construction often prevents many migratory fish (an important food resource in many parts of the world) from reaching spawning and feeding grounds, changes the seasonal flow patterns afterward, and traps sediment in reservoirs to the detriment of downstream habitat, delta lands and nutrient regimes[3] (WWF 2004).

Considering development alternatives to damming and water navigation infrastructure such as ecotourism and rail transport is the first step. Implementing the recommendations of the World Commission on Dams will help equitably develop the economic benefits of river basins while preserving communities, traditional livelihoods, ecosystems, and biodiversity.

[2] In northern Canada, the demand for benefits transported out of basin continues to motivate dam construction in areas already heavily affected by dams (Nilsson *et al.* 2005).

[3] The Nu River is important habitat for aquatic species that thrive in fast-flowing water (Bravard and Gichot 2005)

a Salween, Nujiang or Nu River

i Basin Characteristics

Length: 2,800 Km (Searin no date)
Basin size: 271,914 Km^2 (WRI 2003)
Population: 6 million (WRI 2003)
Population density: 22 people/ Km^2 (WRI 2003)
Key economic activity: fishing and agriculture
Key threats: 16 proposed large dams, ineffective institutions and governance (WWF 2004). Political instability and ongoing civil war exacerbate key threats

The Salween river basin is more than twice the size of England, the second largest river basin in southeast Asia[4] and one of the last free-flowing international rivers in Asia[5] (WWF 2005b; Goichot 2006). Shared by China, Myanmar (formally Burma) and Thailand, 6 million people live in the Salween watershed and depend on the river for their livelihoods, dietary protein, and nutrient rich food particularly during the dry season (IRN 2004). The Salween flows from the Tibetan Plateau adjacent to the Mekong and the Yangtze, in the "Three Parallel Rivers" World Heritage area, at the epicentre of biodiversity in China[6] (Kunming Institute of Botany & University of Bern 2005; IRN 2004). In the upper Salween's Nujiang Prefecture in China, 92% of the population consists of ethnic and religious minorities (Public Open Letter 2005). Along the Thai and Myanmar border, there are over 13 ethnic groups living in traditional communities on the river's banks (EarthRights International 2004). Currently, there is also ample water per person[7] (WRI 2003).

The Salween is home to 92 amphibian species, and 143 fish species of which 47 are found nowhere else in the world; 3 areas support endemic birds (Revenga *et al*. 1998). The Salween delta and associated wetlands support populations of the unique Fishing Cat, the Asian Small-clawed Otter and the Siamese Crocodile (WWF 2005b). It has the world's greatest diversity of turtles including the Giant Asian Pond Terrapin and Bigheaded Turtle (Goichot 2006). On valley walls, terrestrial flora and fauna are well-maintained in often pristine conditions. The Golden Eye Monkey, Small Panda, Wild Donkey of Dulong and Wild Ox still flourish in this basin (Goichot 2006).

One of the first bends of the Salween River as it leaves Tibet to enter Yunnan Province in China (PRC).

[4] The Mekong is the largest river basin in southeast Asia (WWF 2005b).

[5] The Bramaputra is another.

[6] Recognized by UNESCO as a World Heritage Site, the Three Parallel Rivers Region is one of the richest temperate regions in the world (IRN 2004). The area contains over 6,000 different plant species, and approximately 50% of China's animal species including more than 90 amphibian species, over 140 fish species of which roughly one third are endemic, and the world's most diverse turtle community comprised of 10-25 genera (IRN 2004; WWF 2005).

[7] 23,796 m^3/person annually (WRI 2003).

a Salween, Nujiang or Nu River

ii The Threat of Dams on the Salween

Dam construction poses the single greatest threat to the Salween River. China plans up to 13 large hydropower projects in a cascade that would transform the free-flowing river in upper basin into a series of channels and reservoirs (Public Open Letter 2005).

The upper Salween is characterized by high elevation and deep gorges[8], which give it great potential for hydropower generation[9], but also eliminate most options for limiting the severe environmental damage that would ensue (WWF 2004). Nine of the proposed dams are located on the main stem, in national nature reserves, and very close to the UNESCO World Heritage site (IRN 2004). China's Yunnan Provincial Government is proposing one of the highest dams in the world[10] and China appears to be progressing without consultation with the downstream riparian residents in Myanmar or Thailand (IRN 2005; IRN 2004).

Myanmar's government is also planning or has begun several medium to large dam projects along the Salween River (Chiang Mai News 2005). By far the largest and most advanced project is the 228m high Tasang Dam[11] which would create a 640 Km^2 reservoir flooding the lower sections of three major tributaries (Bangkok Post 2006; WWF 2004; Searin no date). Although no needs assessments have been conducted, and the Environmental Impact Assessments are incomplete, the detailed design study is underway (Bangkok Post 2006). Three quarters of the electricity generated by the Tasang would be exported to Thailand[12], and this project is part of wider negotiations for the Greater Mekong Subregion Power Grid (Ruangdit 2004; WWF 2004; Searin no date). As well, last year, Thailand and Myanmar resurrected a proposal to create a 62 Km tunnel along the Thai-Myanmar border to divert 10% of the Salween's flow in Myanmar to the Bhumibol reservoir in Thailand, 300 Km away (McCormack 2000).

There are serious questions as to the safety and economic feasibility of the proposed dams, and risks to the social fabric of the basin residents. Although the slopes surrounding the Salween are more stable than the Mekong, variations in water levels and landslides threaten its banks[13] and China's proposed projects are in a mountainous area which has frequent earthquakes and landslides (Bravard & Goichot 2005; Public Open Letter 2005). China's hydropower cascade would also displace 50,000 ethnic minority people (Environmental News Network (ENN) 2005; IRN 2005). In Myanmar, dam construction and water diversion may be particularly devastating for the indigenous communities because the military government is notorious for human rights abuses[14] (Chiang Mai News 2005). Further, foreign revenue from the exported electricity[15] flowing into Myanmar may be expropriated by the governing junta (Chiang Mai News 2005)[16].

[8] In this region, the 'Three Parallel Rivers' flow within less than 80 Km of one another (Xinhua News Agency 2003).

[9] Theoretical hydropower potential is estimated at more than 100,000 MW (FAO 1999a)

[10] Maji Dam at 300 m (IRN 2005).

[11] 3,300 MW capacity, in southern Shan State (WWF 2004).

[12] In addition, Myanmar and Thailand have already agreed to export 1,500 MW to Thailand by 2010 (WWF 2004).

[13] In fact, there is a relatively large unstable zone in Bingzhonggluo, on the left bank, in the upper basin. Several landslides have occurred in the past already (Bravard & Goichot 2005).

[14] In conjunction with infrastructure projects due to an ongoing civil war between Shan and Karen minority and the ruling military junta. Forced labour, relocation, rape and murder are common methods of intimidation under the guise of 'national development' (Chiang Mai News 2005).

[15] An estimated 3,500 MW, three times what Myanmar currently consumes, from the Tasang Dam alone (Chiang Mai News 2005).

[16] According to the 2003 UN Human Development Report, 40% of Myanmar's budget is allocated to military expenditures, 1.3% on education, and 0.3% on health (Chiang Mai News 2005).

a Salween, Nujiang or Nu River

Responses and WWF Role

The Salween lacks any treaty among riparian countries and each has different and conflicting plans for development in the basin (Yoffe and Ward 1999).

In April 2004, China suspended plans for the construction of 13 dams on the Salween (IRN 2005)[17]. However, the Environmental Impact Assessments for the project have not been disclosed to the public (Public Open Letter 2005). Thus far, environmental groups within China opposing dam construction in the Salween have lobbied authorities through the media, public demonstrations, and the distribution of petitions urging the provincial and national governments to release studies on the dams' environmental impact and allow greater public debate (ENN 2005). On August 31, 2005, 61 groups and 99 individuals including Greenpeace and Friends of Nature, China's largest environmental association, signed a petition. This open debate over the Salween River's fate is testing the government's approach after it released a five-year plan that commits China to halt environment degradation while pursuing economic growth (ENN 2005).

Not-for-profit organizations like Earth Rights International are also raising awareness of human rights and environmental issues (Earth Rights International 2004). In 1999, 'Salween Watch' a coalition of organizations based in Chiang Mai, Thailand formed to oppose harmful development projects in this basin (Salween Watch 2006). In addition, representatives from ethnic groups in Myanmar have urged the Thai government to halt dam development along the Thai-Myanmar border (Shan Sapawa Environmental Organization 2006).

Crystal clear water of a tributary joins the muddy waters of the Salween, exhibiting the high hydropower potential of one of the regions last free flowing rivers.

Some well-planned dam developments for water and energy supply are often justified, but countries should take advantage of the opportunity to consider all options and to only build dams that minimize environmental impacts and maximize social benefits (WWF 2004). Building dams off the mainstream, controlling thermal pollution, and mimicking natural flow patterns (e.g. higher flows during the wet season) can minimize the ecological impact of dams (WWF 2004). In countries where concentrated dam development is taking place, governments should at least implement the guidelines of the World Commission on Dams, and assess the cumulative impacts of the dams. In addition, efforts should be made to retrofit old dams to reduce environmental and social impacts while increasing economic benefits, such as generating electricity.

In China, WWF is working with national authorities to reduce environmental and social impacts of existing and planned dams while increasing economic benefits. WWF calls for further development of small scale hydropower along the tributaries alone, in combination with the development of tourism. The Salween basin has summer temperatures and rich biota suitable for tourism and compatible with local labour development within the natural environment. In addition, it holds the potential for developing the rapids for high-end white water rafting (Goichot 2006).

[17] In 2003, China invited a panel of scientific experts to comment on the Salween Dam proposal and all opposed the dam (IRN 2005).

b Danube

i Basin Characteristics

Length: 2,780 Km (ICPDR 2004)
Basin size: 801,463 Km^2 (ICPDR 2004)
Population: 81 million (ICPDR 2006b)
Population density: 102 people/ Km^2 (WRI 2003)
Key economic activity: industry, navigation
Key threats: new infrastructure for shipping, 8 proposed large dams, flood 'protection' (WWF 2004; ICPDR 2004)
Other threats: pollution, invasive species

The most multinational river basin in the world, the Danube basin is roughly twice the size of California and its basin covers part or all of 19 riparian countries: Albania, *Austria*, Bosnia and Herzegovina, Bulgaria, Croatia, *Czech Republic*, *Germany*, *Hungary*, *Italy*, Macedonia, Moldova, *Poland*, Romania, Serbia, Montenegro, *Slovakia*, *Slovenia*, Switzerland and Ukraine, of which eight are EU member states (in italics) and two are EU accession countries. The river is a principle resource for industry, agriculture, transport and power generation (Environment for Europeans 2004). The Danube delta supports both fishing and tourism (FAO 2000b). Approximately 60 of its 300 tributaries are navigable including the Inn, Morava, Drava, Tisza, Sava and Prut (ICPDR 2006a). It is home to 47 cities[18], and passes through four national capitals: Vienna (Austria), Bratislava (Slovakia), Budapest (Hungary), and Belgrade (Serbia) (WRI 2003).

Historically, the Danube has been home to seven fish species found nowhere else in the world, 10 diadramous[19] fish including five sturgeon species, and altogether 103 fish species, which is more than half of all in Europe (WRI 2003; WWF 2004b). The basin has 88 freshwater mollusks (with 18 found only in this basin) over 18 amphibian species and 65 Ramsar wetlands of international importance (WRI 2003; WWF 2005 - ecoregion). Today only 6.6% of the basin is protected (WRI 2003). The Danube delta on the Black Sea is one of Europe's most ecologically important areas and is shared 80% by Romania and 20% by Ukraine (UNESCO 2005)[20].

Hydro electric power station on the Danube River, Romania. The construction of this dam caused a 35 m rise in the water level of the river near the dam. The old Orsova, the Danube island Ada Kaleh and at least five other villages, totalling a population of 17,000, had to make way. People were relocated, but the settlements have been lost forever to the Danube.

[18] Greater than 100,000 people (WRI 2003).

[19] Fish migrating between freshwater and saltwater.

[20] It is the last European refuge to many rare bird species, harbours a centuries old Letea tropical forest, which is the only place in Europe where climbing 'lianas' plants hang from trees. It is also designated a UNESCO natural World Heritage site. (WWF 2004b; Rus, 2004).

ii The Threat of Navigation Infrastructure on the Danube

Inland shipping infrastructure projects alter natural river function and habitat in several ways. Navigation projects involve physical modification such as water pumping, channelizing, dredging, and gravel and sand extraction to make deep, straight and uniformly banked waterways that partly cut the river off from its floodplain (Revenga *et al.* 2000; Baltzer 2004). Vessel operations also create waves which disturb other water users. For example, young fish are directly affected by waves since their swimming capacity is already low (Zauner & Schiemer 1994). High traffic intensity leads to lowered zoobenthos (animals on the river bed) diversity (Obrdlik 1995). Lastly, inadvertent species introductions, spills and ship collisions pollute and damage aquatic habitats in acute and chronic ways (Baltzer 2004; ICPDR 2006c). Accidental pollution involves oil and in some cases hazardous substances including cadmium, lead, mercury, DDT, lindane and atrazine (ICPDR 2006c).

Navigation infrastructure projects pose a serious threat to the Danube. A new report by a Vienna-based consortium and 13 Danube countries[21] identifies navigation as one of the primary causes of environmental degradation on the Danube, stemming from activities that deepen, dam, or straighten the river (ICPDR 2004). The most important navigation threat to the Danube currently is the European Union's plan to develop the Trans-European Networks for Transport (TEN-T) "Corridor VII" along the Danube (ICPDR 2006c). This project aims to 'remove bottlenecks' and improve inland navigation between eastern and western Europe through the construction of hydraulic modifications and canals (European Barge Union 2005; European Inland Navigation 2004; Commission of the European Communities 2004). According to plans, the Danube will serve as a pan-European transport route linking the North Sea with the Black Sea (ICPDR 2006c). Against the Danube Commission's (1988) recommendations that the total depth of free-flowing conditions should be a minimum of 2.5 m during 343 days per year, dredging will reach a minimum draught of 2.5 m (hence a total depth of 2.7 to 2.8 m) during all days along the entire length of the water course from the North Sea to the Black Sea (European Union 2004; Baltzer 2004). Implementing this project would mean substantial modifications to at least 1,000 Km of the Danube, more than one-third of its entire length, and significantly alter the last free-flowing, non-dammed stretches of the river[22] (Baltzer 2004; WWF 2005; WWF 2005a).

The Danube-Oder-Elbe-Canal Plan is proposed to enable ship passage from the Baltic to the North Sea, then southward to the Black Sea (ICPDR 2004; Baltzer 2004). This will indirectly or directly affect 46,000 ha of 38 protected areas containing two national parks, six Ramsar sites, and two biosphere reserves in five countries Austria, Slovakia, the Czech Republic, Poland and Germany (ICPDR 2004; Baltzer 2004)[23]. Lastly, in 2004, the Ukraine began dredging the Bystroye shipping canal that cuts through the heart of the Danube delta, destroying migratory bird habitat, altering the natural water flow in the delta and damaging breeding areas that support local fisheries in the Black Sea[24] (Baltzer 2004; Rus 2004). Already, the total length of artificially dredged channels in the Danube delta is roughly equivalent to the total length of natural water courses (1,700 Km) (ICPDR 2006c).

Drastic changes to the Danube's natural flow and surrounding lands to control floods, generate power, facilitate agriculture and waterway transport have already destroyed over 80% of the watershed's valuable wetlands, floodplains and forests (ICPDR Dams 2006; UNDP/GEF 1999). What remains of the basin's integrity is under intense threat from shipping infrastructure developments.

[21] Report is entitled *Danube Basin Analysis, WFD Roof Report 2004*.

[22] TEN-T would remove navigation 'bottlenecks' in Romania and Bulgaria by 2011, complete Danube River 'improvement' between Vilshofen and Straubing (in Germany) by 2013, and by 2014 and 2015 respectively affect the river from Palkovicovo to Mohacs as well as the cross-border section from Vienna to Bratislava (Baltzer 2004).

[23] Numerous other portions of this region are included or being nominated for protection under the EU's Birds and Habitats Directives in the Natura 2000 Network (Baltzer 2004).

[24] The Danube is also the single largest contributor of pollution in the Black Sea (ICPDR 2006b).

b Danube

Responses and WWF Role

In 1994, ten basin states and the European Union (EU), signed the Danube River Protection Convention (DRPC)[25] to establish the International Commission for the Protection of the Danube River (ICPDR) (ICPDR 2006; Atlas of International Freshwater Agreements 2003). In its first ten years of cooperation, the DRPC agreed to implement the EU Water Framework Directive, and established a Trans-National Monitoring Network to monitor and evaluate water quality (ICPDR 2004). It made little progress, however, in stemming the pressure to develop navigation projects. In 2004, the European Commission's Director General for the Environment took charge of the ICPDR. In December 2004, the ICPDR produced the Danube basin analysis which, for the first time, provided a basin-wide overview of the river's environmental condition (Environment for Europeans 2004; ICPDR 2004) and promises to use the report in developing a plan for its long term protection (Environment for Europeans 2004).

In 2000 WWF facilitated a heads of state summit of basin governments. They pledged to protect and restore 600,000 ha to establish a 'Lower Danube Green Corridor' of restored riparian lands for nature conservation, water quality improvement, better flood management, and development of sustainable livelihoods for local people. Progress in implementing this commitment has been slow. It is likely, however, that had the pledged restoration been implemented, the floodplains would have mitigated the 2006 lower Danube floods by holding and safely releasing the water. In 2003, WWF completed the official 'Danube River Basin Public Participation Strategy', to contribute towards the implementation of the EU Water Framework Directive in the basin (Jones *et al.* 2003).

Dam on the Danube River.

Floodplain restoration, watershed management and flood warning and evacuation systems allow rivers to continue to provide natural benefits, and are much less expensive than the physically intensive modifications (WWF 2005e). WWF has also begun a public consultation process for the restoration of the river beds of the Danube tributaries in Bulgaria. Following meetings between WWF and the Odessa Oblast Environmental Commission, a Task Force for "cooperation with the Partners for Wetlands project in Ukraine" was initiated and signed by the Odessa Oblast Governor to implement model wetland restoration projects. Due partly to WWF's efforts, removal of a flood levee bank restored 750 ha of Tataru Island, and in spring 2005 a colony of protected Pygmy Cormorants established on the island. A coalition of WWF, other NGOs, Romania and other government partners also secured the Austrian-Czech-Slovak trilateral protected area which later received the Ramsar Convention Award in 2002 (Jones *et al.* 2003).

As a result of international pressure including the European Commission-led, fact-finding mission (initiated by WWF) and the change in Ukrainian government, the construction of the Bystroye Canal stopped temporarily pending further environmental, social and economic impact assessment. In 2005, WWF's Danube-Carpathian Programme created a "black list" of navigation projects along the Danube proposed by the Trans-European Networks for Transport (TEN-T)[26]. WWF is lobbying for a Strategic Environmental Assessment (SEA) and coordination between the European Commission's Directorate of Environment and Directorate of Transport & Energy on navigation projects.

[25] Formally called the 'Convention on cooperation for the protection and sustainable use of the Danube River' (ICPDR 2006).

[26] More information can be found in WWF's position paper (executive summary) on Danube navigation at: http://www.wwf.hu/fletoltes.php?szam=92&tipus=1

c La Plata

i Basin Characteristics

Length: 3,740 Km from the longest tributary of the Paraná (Comite Intergubernamental Coordinador 2006) + 290 Km from confluence of the Uruguay and Paraná Rivers (Rela 2001) = 4,030 Km in total
Basin size: 3 million Km^2 (Bereciartua and Novillo 2002)
Population: > 100 million (Bereciartua and Novillo 2002)
Population density: 33 people/ Km^2 (Bereciartua and Novillo 2002, extrapolation)
Key economic activity: agriculture, fishing
Key threats: new infrastructure and hydrological alterations for shipping and 27 proposed large dams (WWF 2004)
Other threats: climate change, pollution, over-fishing

The La Plata basin is the second largest river basin in South America, crossing five countries: Paraguay, Brazil, Argentina, Uruguay, and Bolivia (Bereciartua and Novillo 2002). The Rio de la Plata basin has three main tributaries, the Paraná, the Paraguay and the Uruguay Rivers. The Paraná tributary river basin supplies the Brazilian cities Sao Paolo and Brasilia (Hulme 1999). Although the Paraná basin alone supports 19 large cities of more than 100,000 people, the per capita water supply per person is ample[27] (WRI 2003).

Freshwater biodiversity is rich. There are over 350 fish species – the third highest among medium sized basins (WRI 2003). Of these, 85 are found nowhere else in the world (Revenga *et al*. 2000). This basin is also home to the rare La Plata River Dolphin (Reeves *et al.* 2003), and the only species of lungfish found in the Neotropics, *Lepidosiren paradoxa* (WWF 2005d). La Plata's Pantanal wetlands, located mostly in southwest Brazil but also extending to southeast Bolivia and northern Paraguay, are the largest freshwater wetland in the world, covering 140,000 Km^2, and home to a vast array of wildlife (Bennett & Thorp no date; Living Lakes Partnership 2005). This biological diversity encompasses 650 species of birds - including parrots, hawks, eagles, kites, 260 species of fish, 90 species of reptiles, over 1,600 species of flowering plants, and over 80 species of mammals - including ocelots, jaguars, and tapirs (Hulme 1999; Living Lakes Partnership 2005). Thousands of permanent and semi-permanent lakes and ponds supporting the most diverse floating aquatic plant community in the world cover the Pantanal's lowest areas (Por 1995 in WWF 2001a). During the wet season, this wetland acts as a gigantic natural control mechanism for the floodwaters of the Paraguay River (Hulme 1999).

Iguaçu National Park - Paraná River Atlantic Rainforest Paraná, Brazil.

[27] 8,025 m^3/person/year (WRI 2003)

ii The Threats of Dams and Navigation Infrastructure on La Plata

The threats from dams and navigation on the La Plata are intense. For example, on the Paraná River, the Itaipu Dam, the largest in the world,[28] flooded approximately 100,000 ha of land, and destroyed significant aquatic habitat including the Guaíra Falls (WWF 2005d). The basin faces the second greatest number of planned dams in the world: 27 large dams[29], of which six are under construction (WWF 2004). In Brazil alone, total generating power from hydroelectric stations is poised to reach a total of 107,307 MW in the next few decades (FAO 2000). In particular, new impoundments and water diversions threaten the Paraguay River's relatively pristine headwaters, which comprise the central artery of the Pantanal wetlands, and Uruguay River (Bleier 1996; WWF 2005d). The Brazilian, Bolivian and Paraguayan governments' plan for the massive navigation and hydroelectric dam project, '*hidrovia*', is proceeding without an adequate Environment Impact Assessment (Bennett & Thorpe no date; WWF 2001a; Istvan 2003). The *hidrovia* would dredge and redirect the Paraguay and Paraná Rivers to create a 3,442 Km long navigation channel at least three meters (~ten feet) deep between Caceres, Brazil and the harbour of Nueva Palmira in Uruguay. This would provide cargo ships with access to the interior of Argentina, Bolivia, Brazil, Paraguay and Uruguay during the dry season (Bennett & Thorpe no date; Istvan 2003; Wolf 2004).

The *hidrovia* threatens to drain and destroy habitat in the Pantanal by increasing the drainage capacity of the river outlet, affect native fish populations, and expose the river system to invasion by exotic species through links to rivers in the Amazon basin (WWF 2004). This would seriously exacerbate the impacts from loss of water inflow due to climate change (Hulme 1999). According to experts, lowering the level of the Paraguay River by only 25 cm on average would increase the frequency of downstream flooding and increase erosion during the rainy season, while also reducing the total flooded area of the Pantanal during the dry season by 22%[30] (Gottgens 2000 in WWF 2004; Bennett & Thorpe no date).

In addition, the *hidrovia* would directly affect local indigenous communities whose livelihoods depend on the fish and biological resources of the Pantanal, particularly in Brazil's Mato Grosso State and in riverine communities in Paraguay (Bennett & Thorpe no date; WWF 2004; International Development Research Center (IDRC) 1999). The *hidrovia* is intended to facilitate expansion of the export of soybean, timber, iron ore and other commodities during the dry season at the expense of the opportunity for ecotourism, and local use of resources (IDRC 1999). It would also increase access and facilitate further dam development in the area (WWF 2004).

[28] Generating capacity of over 12,000 MW (WWF 2004). The Three Gorges Dam plans will surpass it by 2009, with a capacity of 18,200 MW.

[29] Greater than 60m or 100 MW capacity (WWF 2004).

[30] Increased variability in river flows due to changes in climate has caused long periods of drought which has hurt agriculture and hydroelectric energy production in Brazil (American Association for the Advancement of Science 2002).

La Plata

Responses and WWF Role

In 1969, all the riparian countries signed a treaty agreeing to the joint management of the La Plata basin and requiring open transportation and communication along the river and its tributaries (Wolf 2004). The *hidrovia* project is the largest development proposed to date, both in size and scale of possible impacts on the economy and environment (Wolf 2004). The proposal is straining the cooperative processes for management in the La Plata (Wolf 2004). A decade after *hidrovia* was first proposed the supporting governments, particularly Brazil, backed away in 1999, but the project has shown recent signs of revival[31].

For the last decade WWF has concentrated its conservation work in the La Plata Basin through its Pantanal Ecoregion Programme in Brazil and Bolivia and its Atlantic Forests Ecoregion Programme in Argentina, Brazil and Paraguay. WWF has been active in the participation in and/or preparation of economic, engineering and feasibility studies related to the *hidrovia* and other infrastructure proposals that would impact the Pantanal wetlands (Huszar 1999; Halloy 2005). Also in the Pantanal and the Upper Paraguay river basin, in both Brazil and Bolivia, WWF has worked with local stakeholders on improving protected areas management, the formation and strengthening of local organizations, institutional capacity building, environmental education programmes, and the promotion of sustainable productive activities like organic farming, ecotourism and community fisheries management. With help from WWF since 2002, last summer, the Brazilian State of Mato Grasso do Sul and all stakeholders of the Miranda river basin of the Pantanal created the Miranda river basin Committee which ensures multiple use of the basin, while protecting its aquatic biodiversity and water resources (WWF 2006c). WWF also supported socio-economic and biological studies and a consensus meeting[32] which developed the framework for conservation and development in the Bolivian Pantanal over the next ten years. This process led to the creation of two protected areas[33] encompassing most of the Bolivian Pantanal and the remaining Bolivian lowland dry forest. Through work with WWF, Brazil and Argentina conducted collaborative research which led to a joint conservation strategy for over 1 million ha of contiguous Atlantic forest, and is an important step towards cooperative management of the region's Iguazu National Parks. Finally, WWF is seeking to develop representative protected areas in the Brazilian Pantanal, through the use of innovative incentives and policy mechanisms[34], and plans to investigate a range of approaches to participatory involvement for local communities and government authorities.

Aerial view of the Paraná River, Paraná, Brazil.

[31] Argentina and Bolivia are selectively dredging the Paraguay River, Paraguay's government maintains interest in the project, and in Brazil, suspicions abound that large-scale soybean farmers and cattle ranchers are talking about dredging and straightening river sections behind closed doors (Istvan 2003).

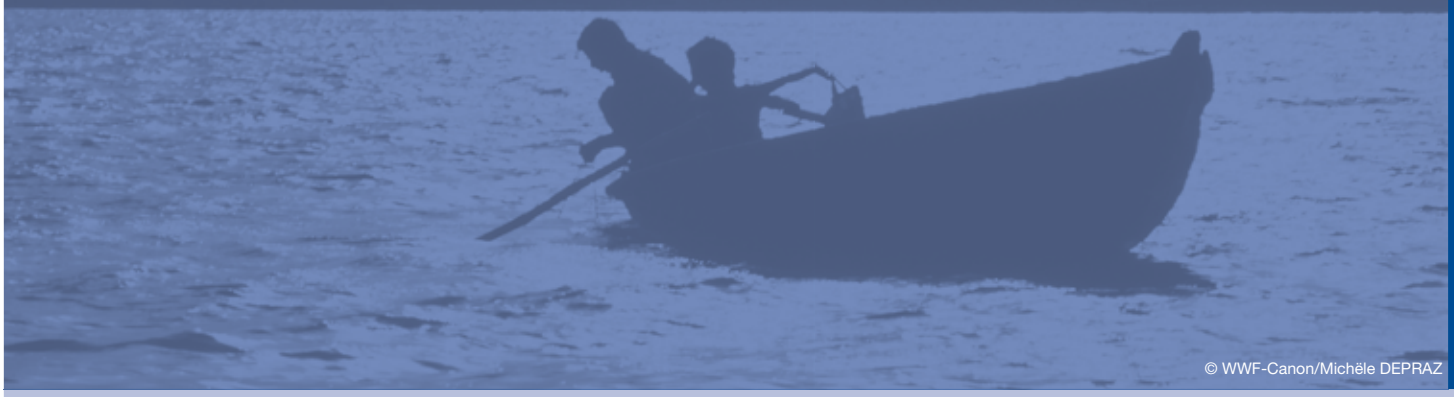
[32] Local indigenous and non-indigenous communities, private industry (forestry and mining), large landowners (ranchers), political authorities, international donors and technical experts all contributed.

[33] Otuquis (1 million ha) and Sans Matmas (2.9 million ha).

[34] WWF-Brazil is encouraging a practice already implemented in some Brazilian states, where tax redistribution compensates municipalities that face restricted land-use due to protected ecosystems and/or water supply sources.

2 Water over-extraction

The Rio Grande (USA) and the Ganges (Asia)



Young boys fishing on the Ganges River. Varanasi, Uttar Pradesh, India.

Although on opposite sides of the globe, the Rio Grande and the Ganges face very similar problems from over-extraction for increasing irrigation and domestic consumption.

Human societies use water for domestic and industrial consumption, however two-thirds are appropriated for irrigation in agriculture (Revenga *et al.* 1998). Reducing the flow of river water to the sea can lead to the intrusion of salt water into surface water and groundwater, rendering them undrinkable (Revenga *et al.* 1998). Experts predict that water availability will be one of the major challenges facing human society and that the lack of water may be a key factor limiting development (Revenga *et al.* 2000).

The total amount of water withdrawn or extracted from freshwater systems has risen 35-fold in the past 300 years (Revenga *et al.* 1998), and since 1960 has increased by 20% per decade (MA 2005a). Agriculture accounts for 70% of human water use (MA 2005a). In addition, around the world, groundwater is also withdrawn faster than it can be recharged, depleting a once renewable resource (Revenga *et al.* 1998).

a Rio Grande - Rio Bravo

Basin Characteristics

Length: 3,033 Km (second longest river in the United States) (Horgan 1991)
Basin size: 607,965 Km^2 (WRI 2003)
Population: 10 million (WRI 2003)
Key economic activity: agriculture
Key threat: water extraction
Other threats: water infrastructure, salinisation, invasive species

The second longest river in the United States, the Rio Grande flows from the San Juan Mountains of Colorado, south through New Mexico. Turning to the southeast, it forms the border between the United States (Texas) and Mexico for approximately two thirds of its course, opening into a small sandy delta at the Gulf of Mexico (United States Geological Service (USGS) no date; Horgan 1991; Saunders 1996). The basin is more than 30% arid and drains an area greater than the size of California (WRI 2003; Saunders 1996; Revenga *et al.* 1998). Through the stretch from Laredo/Nuevo Laredo to the mouth, the river constitutes the primary source of drinking water for communities in both Mexico and the United States (Saunders 1996). Despite the rapidly growing economy, the basin is one of the poorest regions in the US, where many live in shanties without access to running water (WWF 2004d). The basin is facing per capita water scarcity[35] (WRI 2003), and by 2025, will likely descend into further water scarcity[36] (Revenga *et al.* 2000).

The Rio Grande basin is a globally important region for freshwater biodiversity (Revega *et al.* 2000). The Rio Grande supports 121 fish species, 69 of which are found nowhere else on the planet. There are three areas supporting endemic bird species as well as a very high level of mollusk diversity (Revenga *et al.* 1998; WRI 2003; Grommbridge & Jenkins 1998).

The Rio Conchos is the main source of irrigation water for crops (cotton & alfalfa) grown in the state of Chihuahua, Chihuahuan Desert, Mexico.

[35] 621 m^3/person/year (Revenga *et al.* 1998).

[36] Less than 500 m^3/person/year (Revenga *et al.* 2000).

a Rio Grande - Rio Bravo

ii Threat of Water Extraction

A high level of water extraction for agriculture and increasing domestic use threatens the Rio Grande. Most of the major tributaries and many of the lesser ones support substantial agricultural production (Saunders 1996). River water is diverted for irrigation in the El Paso/ Ciudad Juarez area, Eagle Pass/Piedras Negras area, and Rio Grande/Rio Bravo valley downstream from International Falcon Dam (Saunders 1996). In 2005, 451,456,974 m^3 (366,000 acre feet) were diverted from the middle Rio Grande during the irrigation season (Middle Rio Grande Conservancy District 2006). Although this is down from 1999, when total diversions in the middle Rio Grande were 837,869,606 m^3 (679,268 acre-feet), nearly all of the irrigation water in the upper basin, is produced by snow pack (Alliance for the Rio Grande Heritage *et al*. 2000). Several years of low snow pack has dramatically lowered the volume of the most important reservoir on the mainstem, Elephant Butte Reservoir. With current levels of extraction, this reservoir could be at its lowest in over 50 years, at to 43,172,115 m^3 (35,000 acre feet).

Historically, flows passing through Big Bend have varied considerably (NPS 2006), but by the time the Rio Grande leaves El Paso, a city less than one third the length of the river at this confluence of the Rio Conchos, so much water has been diverted that the riverbed between El Paso and Presidio/Ojinaga often lies dry (NPS 2006). The highest daily flow recorded above the Rio Conchos confluence was 387,984 L/s (13,700 cubic feet per second) on June 1905 (NPS 2006). Pre-1962, the river's average flow was 2.9 Km^3/year (2.4 million acre-feet) and ocean-going ships used to be able to navigate at least 16 Km (10 miles) from its mouth (Brezosky 2001). In 2005, at the last gauge point before the sea, in Brownsville Texas, however, the average flow was 0.44 Km^3/year (International Boundary & Water Commission 2005)[37]. Between February and June 2001, the river failed to reach the Gulf of Mexico (Sundquist 2003; The Guardian 2006). As a result of low water levels, the concentration of pollutants is so high that fish kills have occurred, and the lower Rio Grande is suffering from salinization (Contreras & Lozano 1994). In fact, some marine fish species are invading as far as 400 Km upstream, and the increasing salinity of the river has already displaced 32 native freshwater fish species (Contreras & Lozano 1994).

Irrigation accounts for more than 80% of all water taken from the river, but municipal needs are competing more and more as urban areas grow (Cascadia Times 2005). Along the Rio Grande mainstem, there are only four major cities[38], but the urban population is growing at a rapid rate of 2-4% (WRI 2003; Revenga *et al.* 1998). Water is also wasted through unnecessary diversion: the amount of water diverted and wasted by dams for irrigation increased by over 123,348,900 m^3 (100,000 acre feet) per year from 1979-1998 (Alliance for the Rio Grande Heritage *et al*. 2000).

Damming, high levels of evaporation[39], persistent drought and invasive species have exacerbated the high level of water extraction (Dahm *et al*. 2000; National Park Service (NPS) 2004). Extensive networks of water diversions and dams control flows in both the Rio Grande and its key tributary, the Rio Conchos, without managing instream flow to sustain riparian habitat (Mac *et al*. 1998). Currently, there are 100 large dams[40], eight of which are on the main stem of the river, and there are six very large dams[41] (WRI 2003). Drought has caused crops to wither which has led to severe malnutrition among the Tarahumara Indians in the highlands of the Chihuahua (NPS 2006). The invasive species Salt Cedar, has proliferated through large portions of the Big Bend area (where the Rio Conchos joins the Rio Grande), and is known to consume large quantities of water (Dahm *et al*. 2000). One monoculture of Salt Cedar is believed to have choked 150 miles of the river corridor downstream of El Paso/Ciudad Juarez and may be the most extensive infestation of this species in the world.

[37] Despite the relatively strong social stability and institutional capacity to manage water in this basin, basic hydrologic data including the portion of the river's flow that reaches the sea and the portion that is diverted, are not available.
[38] With a population greater than 100,000 (WRI 2003).
[39] 271,260,000 m^3/year (Dahm et al. 2000).
[40] Higher than 15 m.
[41] Higher than 150 m.

Rio Grande - Rio Bravo

Responses and Role of WWF

WWF is working to promote more efficient irrigation practices and restoration of environmental flows in both the mainstem of the river and its most important tributary, the Rio Conchos. Our work in the Rio Conchos begins in the headwaters, in the Sierra Tarahumara, where we have helped establish protected areas, implemented community-based problem solving workshops and processes, and funded local water conservation projects.

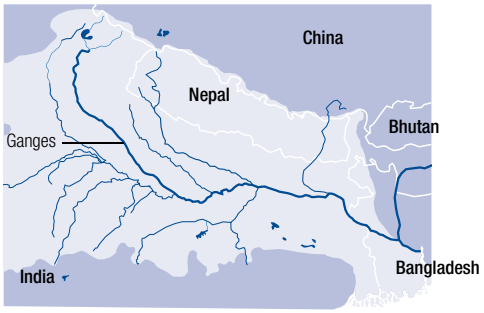
Our community-based work joins WWF with indigenous communities as well as small, with self-governing communal land organizations. Moving down stream, WWF is developing a payment scheme for downstream water users who would pay for better upstream watershed management. Along the mainstem, we are working with commercial agriculture interests to develop water conservation techniques for cotton, pecan and chili pepper production.

Complimentary work in the policy arena is focused on creating institutions and sources of funding that can acquire water “saved” in agriculture and apply to environmental purposes such as wetlands or in-stream flow. In addition, WWF is working to eradicate the water-hogging invasive Salt Cedar and has restored former floodplain habitat that had been infested with this species.

b Ganges

i Basin Characteristics

Length: 2,507 Km (Newby 1998)
Basin size: 1,016,124 Km^2 (WRI 2003)
Population: roughly 200 million people (Welcomme & Petr 2004)
Population density: average 401 people/ Km^2 (WRI 2003)
Key economic activity: agriculture
Key threats: water extraction, 14 proposed large dams (WWF 2004)
Other threat: climate change



The Ganges river basin runs from the central Himalayas to the Bay of Bengal, and covers parts of Nepal, India, China and Bangladesh (Newby 1998; WRI 2003). The Ganges flows through northeastern India to the Bangladesh border, east-southeast 212 Km to its confluence with Brahmaputra, and continues as the Padma River for another 100 Km to its confluence with the Meghna River at Chandpur (Food & Agricultural Organization (FAO) 1997; FAO 1999). The basin occupies 30% of the land area of India (Revenga 1998; United States Central Intelligence Agency 2006) and is heavily populated, increasing in population density downstream to Bangladesh, the most densely populated country in the world (WRI 2003; Rashid & Kabir 1998). Approximately one in twelve people in the world (8%) live in its catchment area (Newby 1998). The cultural and economic significance of the Ganges is enormous. The river is a centre of social and religious tradition (Adel 2001) and is particularly sacred in Hinduism.

The Ganges river basin contains high biodiversity. There are over 140 fish species, the richest freshwater fish fauna in India (Jones *et al.* 2003; WRI 2003), 90 amphibian species, and five areas supporting birds found nowhere else in the world. The basin is home to five species of freshwater cetaceans including the endangered Ganges River Dolphin which faces an annual mortality rate of 10% (WRI 2003) and the rare freshwater shark, *Glyphis gangeticus* (Martin 2003). The unique Sundarbans delta mangroves are found where the Brahmaputra River and Meghna River converge in the Bengal basin (Wilkie & Fortuna 2003; UNESCO 1998) and support over 289 terrestrial, 219 aquatic, 315 bird, 176 fish and 31 crustacean species (Ramsar Convention on Wetlands 2001). There are also 35 reptile and 42 mammal species, including the world's last population of the mangrove-inhabiting tigers, *Panthera tigris* (WWF 2005c). Together the Brahmaputra and Ganges watersheds span 10 biomes and contain the widest diversity of all large river systems as classified by Nilsson *et al.* (2005).

b Ganges

ii Threat of Water Extraction on the Ganges

Water withdrawal poses a serious threat to the Ganges. In India, barrages control all of the tributaries to the Ganges and divert roughly 60% of river flow to large-scale irrigation (Adel 2001). India controls the flow of the Ganges into Bangladesh with over 30 upstream water diversions. The largest, the Farraka Barrage, 18 Km from the border of Bangladesh, reduced the average monthly discharge of the Ganges from 2,213 m^3/s to a low of 316m^3/s [14%] (Goree 2004; FAO 1999). The Tehri Dam, which has been under construction since 1978 (IRN 2002), became operational in 2005 and is the 5th largest dam in the world (IRN 2002; Oko 2004). Two hundred miles northeast of Delhi, its reservoir completely submerged 40 villages and the old Tehri town, (IRN 2002), causing the resettlement of 100,000 people (Oko 2004). Tehri Dam provides 270 million gallons of drinking water per day, irrigates thousands of acres of farmland and generates 2,000 megawatts of electricity mainly to the Uttar Pradesh and Delhi (Oko 2004; Bisht, 2005). This is part of the 'garland of rivers' project in which the Indian government plans to link 37 major rivers (including all the major rivers flowing from the Himalayas). The rivers would be linked through a series of dams and canals spanning the subcontinent[42] to provide stable drinking water supplies to urban and rural populations and harness some 34,000 MW of hydroelectricity (Oko 2004). In this US$125 billion 'interlinking of rivers' scheme, India proposes to divert vast quantities of water from the Ganges (and Brahmaputra) to support water and agriculture needs of the drought-prone states in the south and east. This would further aggravate water poverty in Bangladesh (Indian Council of Forestry Research & Education 2003). In addition, governments along the Ganges are heavily subsidizing electricity for tube well pumps, plan to expand surface water irrigation, and ban distribution of all surface water diversion data (International Water Management Institute 2002; Adel 2001; FAO 1999).

Over-extraction for agriculture in the Ganges has caused the reduction in surface water resources. This has increased dependence on ground water, the loss of water-based livelihoods[43], and the destruction of habitat for 109 fish species, and other aquatic and amphibian fauna (Adel 2001). Lowering water levels have indirectly led to deficiencies in soil organic content, and reduced agricultural productivity (Adel 2001, Revenga *et al.* 2000). Lastly, over-extraction of ground water has seriously affected water quality. Inadequate recharging of groundwater impairs the natural cleansing of arsenic which becomes water soluble when exposed to air, and threatens the health of 75 million people who are likely to use water contaminated with up to 2Mg/L of arsenic (Adel 2001)[44]. Climate change will exacerbate the problems caused by water extraction. The Himalayan glaciers are estimated to supply 30-40% of the water in the Ganges, which is particularly critical in the dry season prior to the monsoon rains.

The projected annual renewable water supply for 2025 indicates water scarcity[45] (Revenga *et al.* 2000). Although the Ganges catchment drains virtually all of the Nepal Himalayas and water supply per person in the basin ranges from adequate to ample[46], its dry season outflow (from December to February) to the sea is non-existent (FAO 1999; Revenga *et al*. 2000). Overall, excessive water diversions threaten to eliminate natural flows and severely damage people's livelihoods in the Ganges.

[42] This would involve building hundreds of reservoirs on principle tributaries to the Ganges, digging more than 966 Km (600 miles) of canals, possibly flooding more than 7,770 Km^2 (3,000 sq miles) of land, and uprooting 3 million people from their land (Indian Council of Forestry Research & Education 2003).

[43] Including those of boatmakers, fishing equipment makers, transportation providers, and tourist site operators (Adel, 1999).

[44] Over-extraction has caused the ground water in states such as Uttar Pradesh and Haryana to have nitrate concentrations 5-16 times the safe level. In Haryana, concentrations are 30 times the prescribed limit (Revenga *et al.* 2000).

[45] Less than 1,700 m^3/person/year (Revenga *et al.* 2000).

[46] 1,700-4,000 m^3/person/year (Revenga *et al.* 2000).

b Ganges

Responses and Role of WWF

Typical daily scene along the Ganges River, people bathing and performing their ritual ablutions. Varanasi, India.

In 1996, a 30-year Ganges Water Sharing Treaty was finally agreed between India and Bangladesh (Transboundary Freshwater Dispute Database 2002). Its ineffectiveness however is evident, as India progresses with its river linking project (Indian Council of Forestry Research & Education 2003).

To reduce the threat of excessive water extraction, countries can irrigate crops more efficiently, use local knowledge, end perverse subsidies, cap water extraction levels, further community education and awareness, and support integrated river basin management (WWF 2005e). WWF has instigated a new initiative on freshwater to foster sustainable utilization and conservation of water for future generations. It is currently building a network of partnerships between government agencies, NGOs and freshwater professionals to support monitoring, policy work and restoration projects at different scales. WWF aims to achieve biodiversity conservation within the broader context of sustainable development and poverty reduction.

3 Climate change

The Indus (Asia) and the Nile-Lake Victoria (Africa)

Cormorants at the Lake Victoria source of the Nile.

The Indus faces threat from climate change because of its high dependency on glacier water. The Nile basin is very sensitive to increases in temperature because of its high rate of evaporation.

Freshwater systems are highly sensitive to variations in weather and climate. The accumulation of greenhouse gases in the atmosphere causes global climate change and affects patterns of precipitation, evaporation, snowpack, flood, drought and other factors affecting freshwater supply and quality (Kundzewicz & Mata 2003; IPCC 2001a; Miller no date). Although there will be certain changes in the quantity and distribution of precipitation and runoff, the local and regional impacts are uncertain. Climate change should be considered in the context of the many other stresses to water resources (Kundzewicz & Mata 2003; IPCC 2001a; Miller).

a Indus

i Basin Characteristics

Length: 2,900 Km (Encyclopædia Britannica 2006)
Basin size: 1,081,718 Km^2 (WRI 2003)
Population: 178,483,470 people (WRI 2003)
Population density: 165 people/ Km^2 (WRI 2003)
Key economic activity: agriculture
Key threat: climate change
Other threats: water extraction[47], agricultural pollution, water infrastructure, 6 proposed large dams (WWF 2004)

The Indus river basin spans parts of four countries (Afghanistan, Pakistan, India and China) in an area that is more than 30% arid, and much drier than the nearby Ganges river basin (WRI 2003). The Indus River is critical for Pakistan's 160 million people, and irrigates 80% of its 21.5 million ha of agricultural land (Rizvi 2001; CIA 2006a)[48].

The watershed is also an area of rich biodiversity, particularly where it opens to the Arabian Sea. The Indus river delta is a highly productive area for freshwater fauna and an important region for water birds (Ramsar Convention on Wetlands 2003). The Indus is home to 25 amphibian species and 147 fish species of which 22 are found nowhere else in the world. It harbors the endangered Indus River Dolphin, one of the world's rarest mammals, with a population of no more than 1,100 individuals (WRI 2003; Ramsar Convention on Wetlands 2003; WWF 2005f). Due to reduced river inflows, the delta has lost significant portions of its mangroves (WWF 2004).

[47] Ranked most serious threat to the basin by WWF Pakistan.

[48] The remaining 20% of water used for agriculture comes from rain, especially during the monsoon season from July to September (Rizvi 2001).

ii The Threat of Climate Change to the Indus

The Indus River is extremely sensitive to climate change due to the high portion of its flow derived from glaciers. Temperature controls the rate of glacier melt, which in turn, provides more water in dry, warm years and less water in cool years. River catchments with a large portion of glacial melt water experience less variability in water flows. With climate warming, many glaciers will no longer exist to moderate the flow of these rivers. Thus communities which depend on glacier water will face more severe water shortages, variability and potentially greater flooding too (IPCC 2001a; WWF 2005g; Rizvi 2001). The Himalayan glaciers provide the Indus with 70-80% of its water (Kiani 2005), the highest proportion of any river in Asia. This is double the proportion of water that they provide the Ganges (30%-40%). Himalayan glaciers provide 44.8% of the water in the Upper Indus in China alone (Yang 1991).

The Indus basin is already suffering from severe water scarcity due to over-extraction for agriculture, causing salt water intrusion in the delta (WRI 2003). In 1995, the Indus River already supplied much less water per person than the minimum recommended by the United Nations (UN)[49] and by 2025 is predicted to suffer even more severe water scarcity[50] (Revenga *et al*. 2000).

Well-managed riparian forests are especially important in minimizing the impacts of climate change on river biota. They provide shade and temperature regulation, can moderate the effect of frequent, short duration storm events and can support natural water flow regimes. However, the Indus basin has already lost over 90% of its original forest cover (Revenga *et al*. 1998; WRI 2003). Climate change will exacerbate the impact of deforestation on water regulation. Although the Indus system is currently robust enough to cope with shortages of 10-13% in river flows, when the rivers flow drops to 15-20% below the average, irrigation shortages occur (Khan 1999). Climate change will surely exacerbate the problems of irregular and low flow.

Indus River, Sukkur, Province of Sind, Pakistan, January 2005.

[49] In 1995, the Indus provided only 830 m^3/person/year, compared to the UN minimum standard of 1,000 m^3/person/year (Revenga *et al.* 2000).

[50] Projected annual renewable water supply is less than 500 m^3/person/year (Revenga *et al.* 2000).

Responses and Role of WWF

In 1990, all Pakistani provinces in the basin signed a water accord, and the Pakistani government ensured at least 10 million acre feet (MAF) of water to be available for the delta each year, but has since not followed up on this promise (Ahmad 2004). In fact, the Pakistani government provides water subsidies for agricultural development and is proposing the construction of another six large dams. National Environmental Quality Standards exist, but Pakistani environmental protection agencies do not enforce them effectively (Ahmad 2004). Coastal residents have been unable to raise the issue of water supply through their representatives in the national parliament (Ahmad 2004). Currently three public sector organizations manage surface water resources and delivery: the Indus River System Authority, the Pakistan Water and Power Development Authority, and the provincial irrigation departments in Pakistan. However there is no effective method to ensure adequate distribution (Khan 1999). In addition, although more than 30 different departments, institutions, and NGOs are working on different aspects of resource management in the Indus River and delta, this knowledge is rarely shared or disseminated to the relevant stakeholders (Ahmad 2004).

WWF is developing a long-term conservation programme, ranging up to 50 years, focusing on freshwater scarcity in the coastal areas of the Indus delta (Ahmad 2004).

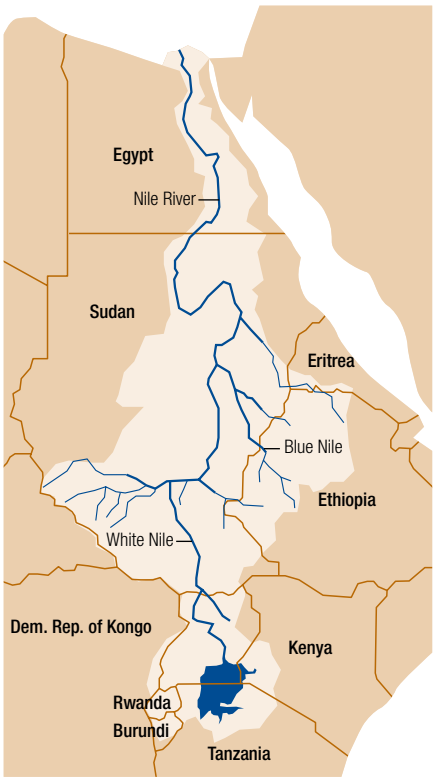
Although both Pakistan and India are grappling with mitigating the effects of climate change, Pakistan's contribution to greenhouse gas emissions are dwarfed by those of wealthier and more industrialized nations such as Canada, the United States and Australia. It is essential that the global community work together to implement emissions reductions. WWF is working to strengthen the ability of developing countries[51], such as India and Pakistan to effectively participate in and foster the implementation of the UN Framework Convention on Climate Change (FCCC) by mobilizing relevant and influential stakeholder groups in key countries. In addition, WWF is implementing a programme to ensure public and private investments in developing countries in the Asia/Pacific region to: support the objectives of the FCCC, support technology transfer, climate change mitigation and impacts awareness raising in Asian developing countries, and create a process of developing country participation in the FCCC process. These efforts involve export credit agency reform to promote clean investment, and strengthening the clean development mechanism to support low-emission technologies.

[51] 'Non-annex 1' countries. (IPCC 2001a).

b Nile-Lake Victoria

i Basin Characteristics

Length: 6,695 Km (WWF 2001)
Basin size: 3,254,853 Km^2 (WRI 2003)
Population: 360 million (Rowley 2005)
Population density: 46 people/ Km^2 (WRI 2003)
Key economic activity: agriculture
Key threat: climate change
Other threats: excessive water extraction, invasive species



The Nile River-Lake Victoria basin falls within ten countries (Sudan, Ethiopia, Egypt, Uganda, Tanzania, Kenya, Rwanda, Burundi, Democratic Republic of Congo, Eritrea) (WRI 2003), and is roughly the size of India. The Nile is also the longest river on earth, and meanders through a watershed that is more than 30% arid (Encyclopedia Britannica 2006a; Revenga *et al*. 1998). The longer of two branches, the White Nile, extends from the mountains east of Lake Tanganyika, through Lake Victoria, to the Nile delta at the Mediterranean Sea (WWF 2001). The shorter branch, the Blue Nile, springs from the Ethiopian Highlands, joining the longer branch in central Sudan, and contributes the majority of water entering Egypt (WWF 2001)[52].

People have been farming intensively in the Nile river basin for more than 5,000 years. Today, there are 25 large cities with more than 100,000 people. The Nile delta is home to virtually all of Egypt's 78 million people, where the average population density ranges from 1,000 person/Km^2 to much higher in major cities, such as Cairo (WRI 2003; WWF 2001; United States Central Intelligence Agency 2005). Although the water supply per person is currently ample[53], the Nile is one of six river basins in the world with a projected population exceeding 10 million that is predicted to face water scarcity by 2025[54] (Revenga *et al.* 2000).

The Nile river basin is home to a bountiful array of biodiversity including 137 amphibian species, 69 wetlands that are important bird areas (IBAs), and five areas supporting birds found nowhere else in the world (WRI 2003). The Nile delta is one of the world's most important bird migration routes and is a breeding ground for two endangered marine turtles, the Loggerhead and the Green Turtle (Denny 1991; Schleich *et al.*1996). The Nile River alone supports 129 fish species, of which 26 are located only in this watershed. Lake Victoria sustains a remarkable 343 fish species and 309 endemic fish species, which make it the highest globally in both categories[55] (Revenga *et al*. 2000).

[52] The Blue Nile contributes roughly 84% of the water above Egypt's Aswan High Dam (WWF 2001).

[53] Per capita water supply is 2,207 m^3/person/year, 1995 (WRI 2003).

[54] Less than 1,000 m^3/person/annually (Revenga et al 2000).

[55] For lakes with an area of less than 400,000 Km^2 (Revenga et al. 2000).

ii Threat of Climate Change to the Nile-Lake Victoria

Due to heavy human extraction and high evaporation, the Nile river basin and its inhabitants are especially sensitive to climate change. Current water withdrawal for irrigation is so high, that despite its size, in dry periods, the river does not reach the sea (WWF 2004c). In addition, along its 3,000 km course through arid northern Sudan and southern Egypt, the Nile loses a huge amount of water to evaporation (United Nations Environment Programme (UNEP) 1993). This makes water supply extremely sensitive to temperature and precipitation changes. Climate warming models provide diverging pictures of future river flows in the Nile from a 30% increase to a 78% decrease (IPCC 1997; IPCC 2001; Olago 2004). In addition, saltwater intrusion into coastal freshwater resources (including aquifers) is likely to increase as a result of sea-level rise due to climate warming (IPCC 2001; Miller no date) and would further reduce the availability of freshwater in the delta region. Climate change may make Egypt drier and warmer, intensifying its dependency on irrigation[56] (UNEP 1993). In light of the high and growing human demands for water and water-intensive agriculture on the banks of the Nile, reduced water flows under climate change would be catastrophic.

Climate change will also have a significant impact on fisheries, affecting both the productivity of fish populations and how they are distributed (Environment Canada 2005). Small changes in temperature can dramatically alter water levels, mixing regimes and fish productivity (IPCC 1997). This may result in increased fish productivity in the short term, but not indefinitely (IPCC 2001). Higher temperatures in Lake Victoria can result in slackened winds, less intense mixing, and changes in the nutrient dynamics which would affect fisheries productivity and completely alter the trophic structures of fish communities (O'Reilly *et al.*, 2003; Verburg *et al.*, 2003; ENSO Project 2003 in Olago 2004). Sporadic upsurges of the 'oxycline' threshold in the water column, below which waters are starved of oxygen, have risen to depths as shallow as 10 m in Lake Victoria, and have already been associated with fish kills (Ochumba 1996 in Olago 2004). Reduced fish production could affect food availability, aggravate poverty and possibly exacerbate political instability in the region.

Lastly, the Nile basin traverses the largest number of countries of any basin in Africa; changes in the timing and availability of water under climate change may lead to tension, insecurity and management problems (IPCC 1997). Currently, Egypt and Sudan have full water extraction rights of the Nile[57], and have threatened to use force on upstream nations that implement water diversions (Singh *et al.* 1999 in WWF 2001; IPCC 1997). A reduction over 20% of Nile River flows would make this agreement impossible to implement and result in serious social and economic problems (IPCC 1997). Already, more than half of the Nile's basin countries receive more than 90% of their electricity from hydropower, another three are 70% dependent on hydropower (IRN 2004a) and these countries have experienced power shortages during recent droughts. Further, the recent peace agreement in Sudan may facilitate development in that country that will require expansion of water use.

[56] The Egyptian government is already attempting to convert desert to agriculture; this new farmland is inefficient and water-intensive (UNEP 1993).

[57] Due to a colonial era treaty (Singh *et al.* 1999 in WWF 2001; IPCC 1997).

Responses and Role of WWF

In 1999, the basin countries established the Nile Basin Initiative (NBI), a regional partnership to facilitate the sustainable development and management of Nile resources (NBI 2005). The NBI seeks to invest in and improve stakeholder involvement, and power market coordination among basin countries, socio-economic benefit-sharing both today and in the future, integrated water management training, and water use efficiency in agriculture (NBI 2005).

Unfortunately, climate change complicates the relations between Nile Basin Initiative states. Under the Shared Vision Programme, the Nile Basin Initiative seeks to work with basin countries to conduct long term planning to protect the river, increase their capacity to provide needed energy and water, and become more resistant to climate change.

In the Mara river watershed in Kenya and Tanzania, which drains into Lake Victoria, WWF is facilitating stakeholder dialogue on integrated river basin management for regional and district government institutions, non-governmental organizations and communities. This includes work to: protect the forest sources of the river on the Mau escarpment, model environmental flows, and develop water sharing agreements needed to sustain people and nature along the river.

The Lake Victoria source of the Nile. The river originates from two distinct geographical zones, the basins of the White and Blue Niles.

WWF also works globally to mitigate climate change and to identify sustainable energy sources. WWF is developing a small project that will examine the effects of climate change on freshwater resources in the Mara river basin. This project will conduct an assessment of impacts, develop locally acceptable adaptation mechanisms, communicate climate testimonials and engage policy makers. WWF is also implementing an environmental education programme in the Lake Victoria basin that aims to sensitize local communities and governments on the changing situation of the lake and its catchment.

4 Invasive species

The Murray-Darling (Asia-Pacific)

Flooded forest along Murray River near Tocumwal.

An invasive species is a plant or animal that is intentionally or unintentionally introduced to a region in which it did not naturally evolve, and where in its new environment, it grows to out-compete native species and communities.

Invasive species threaten the biological fabric of river basins. A survey of 31 fish introductions in Europe, North America and Australia and New Zealand shows that in 77% of cases, native fish populations were reduced or eliminated following the introduction of non-native fish (Revenga *et al.* 1998). Islands and their freshwater systems are particularly sensitive to invasive species, and Australia's Murray-Darling basin is no exception.

a Murray-Darling

i Basin Characteristics

Length: 3,370 Km (Australian Government 2005)
Basin size: 1,050,116 Km^2 (WRI 2003)
Population: 2 million (extrapolated from WRI 2003)
Population density: 2 people/ Km^2 (WRI 2003)
Key economic activity: agriculture, grazing, tourism (Australian Government 2003; Murray Darling Basin Commission (MDBC) 2006)
Key threat: invasive species, especially from aquarium trade
Other threats: river regulation & fragmentation, salinization, climate change

The Murray and Darling Rivers cross four Australian states and one territory, draining roughly 14% of Australia's land mass. The source of the Murray, which contributes the majority of the system's total discharge, is in the Australian Alps (MDBC 2006a). The Murray-Darling river basin is a vital source of water for the major cities of Adelaide and Canberra, but it is more than 30% arid (WRI 2003). The Murray and Darling Rivers have great variability in year to year flows, and their ecology is driven by large floods covering their extensive floodplains and intervening dry periods (MDBC 2006a). Compared to other major river systems the in the world, the Murray-Darling is large in terms of its length and catchment area, but small and erratic in terms of discharge, and surface runoff (MDBC 2006a).

Despite these variable conditions, the Murray-Darling is home to abundant aquatic plant and animal life. In the Murray-Darling basin, there are around 30,000 wetlands, 12 of these are internationally recognized Ramsar sites (Australian Government 2005a). The basin is known for its diversity of crayfish and freshwater snails (Revenga *et al.* 2000; WRI 2003), and is home to 16 mammal and 35 bird species that are nationally endangered (Australian Government 2005a). Despite the relatively low number of endemic fish species (seven in total), it is home to flagship species such as the Silver Perch, Freshwater Catfish and the large Murray Cod all of which are in rapid decline (WRI 2003; Barrett 2004).

Flowering Lippia infestation along banks of Namoi River, near Boggabri, NSW, February 2004.

ii Threat of Invasive Species in the Murray-Darling

In the past century, native fish species in the Murray-Darling basin have undergone a serious decline in distribution and abundance, while that of invasive species has significantly increased (MDBC 2005). In fact, native fish populations are roughly 10% of their pre-European settlement levels (Murray Darling Basin Ministerial Council 2003; Philips 2003 in Barrrett 2004). Nine of the 35 native fish species are nationally 'threatened', two are critically endangered, and 16 are threatened under state jurisdictions (Barrett 2004). In contrast, both the invasive European Carp and Plague Minnow are now abundant (Australian Government 2004). This is likely a result of significant changes in water flow, thermal (cold water) pollution, instream habitat degradation, and barriers to fish passage which have fostered conditions favourable to invasive species over native fish populations (MDBC 2005). At least 11 introduced fish species make up one quarter of the basin's total number of fish species, including the Brown Trout, Rainbow Trout, Redfin Perch, Gambusia, and Goldfish (Australian Government 2004; Harris and Gehrke 1997 in Barrett 2004).

In 30 years since its introduction, however, the European Carp has become the predominant biomass in the Murray-Darling (Australian Government 2004; Barrett no date). At many sites, carp account for an estimated 60-90% of the total fish biomass, with densities as high as one carp per square meter (Australian Government 2004; Harris & Gehrke 1997 in Barrett 2004)[58].

Due to the high level of water regulation and fragmentation in the Murray-Darling, carp's ability to breed in turbid water in the absence of the natural flood and drought cycle, give it a biological advantage over native fish species (Sinclair 2001 in Olivier 2003). Irrigated agriculture accounts for 95% of water diversion in the Murray, covers almost 1.5 million ha in the Murray-Darling basin, and has severely damaged the rivers' ecology (Murray Darling Basin Commission 2006c). Extensive dam and weir development for agriculture creates barriers to native fish migration, extracts half of the annual stream flow in the Murray[59], and increases periods of low flow[60]. Such development also causes permanent flooding and high water in some areas, increases sedimentation, and reverses the seasonality of natural flows (Murray Darling Basin Ministerial Council 2003; MDBC 2006b; Australian Government 2006). In addition, carp change the natural habitat by uprooting the vegetation upon which native fish depend for habitat and food (Sinclair 2001 in Olivier 2003). Carp also muddy the water in which they feed, which blocks the photosynthetic growth of native aquatic plants. Unlike native fish, these invasives have fleshy barbs which are well-adapted for searching for food in murky waters (Sinclair 2001 in Olivier 2003). Compounding this damage, periodic unnaturally cold water released from dams in the headwaters of all but three river tributaries prevent 'warm water' native fish from breeding for around 300 Km downstream (Victorian Government 2001; New South Wales Government 2001). For example, localized extinction of the Trout Cod, Murray Cod and Macquarie Perch has occurred 100 Km downstream following completion of the Dartmouth Dam (Barrett 2004), the last major dam built in the basin. Removing 'snags' (fallen trees and branches) from the watercourse also reduces the habitat quality and breeding success of native fish while increasing the competitive advantage of invasives (Murray-Darling Basin Ministerial Council 2003; Barrett 2004). Carp also spawn in the many vegetated irrigation channel systems in the Murray-Darling River system (Victorian Government 2001).

The Mosquito Fish or Plague Minnow is another serious threat to native fish in the Murray-Darling. An aquarium fish that was introduced in the 1920's to prey on mosquitoes as it did in the Rio Grande, this species has had no impact on mosquito prevalence, but attacks, injures and preys on native fish (Australian Government 2004). It nips the fins of other fish, leaving open sores which spread pathogens among fish, and competes with them for food and habitat (Olivier 2003; Australian Government 2004). The Mosquito Fish also feeds on native fish fry at the water's surface and preys on the eggs and attacks the tadpoles of native frogs (Olivier 2003; Australian Government 2004)[61].

Continued

[58] Originally from central Asia, the European carp grows up to 60Kg (Olivier 2003).

[59] Total of 11,000 GL of water per year (MDBC 2006).

[60] So much water has been extracted that the river mouth has only been linked to the sea by dredging (Kemp & Truss 2002).

ii Threat of Invasive Species in the Murray-Darling (continued)

Speaking of aquarium fish released into the Murray-Darling, this is now the largest source of new feral freshwater fish in Australia (Olivier 2003; Australian Biosecurity Group 2005). Since 1990, the number of exotic fish in Australia's waters overall jumped from 22 to 34, and all except for one of these introduced species originated from the aquarium trade (Australian Biosecurity Group 2005).

Compounding damage to the Murray-Darling, are invasive plants including water plants released from aquariums and ponds, riparian trees introduced for aesthetic purposes, and a variety of plants introduced for agricultural and ornamental purposes that are invading floodplains and other wetlands. One example is Lippia, introduced as an ornamental 'no mow' lawn. This unpalatable herb is smothering the river system's floodplain. These plants reduce the natural productivity of the floodplain, river and other wetland habitats, further depleting natural wildlife populations.

These invasive species reflect an ongoing governance failure common to most countries. While the Australian Government has long had some quarantine controls, they have not adequately excluded new introductions of dangerous species. Most importantly, Australian governments have failed to adequately screen the many exotic species already in the country – legally and illegally - and undertake 'incursion management', to kill dangerous species while their populations are still low. Also better 'vector controls' to manage the sources of these exotic species are missing, such as programmes directed at aquaculture and at the aquarium trade to regulate and prevent release of alien fish and plants. Instead most state (provincial) governments have focused on ineffective and expensive 'control' programmes, when these alien species have invaded too thoroughly to be eradicated.

[61] Incidentally, the Murray-Darling is facing a noticeable amphibian decline with the loss of 5-8 amphibian species from two different locations (Revenga et al. 2000). In addition to the possible role of Mosquito Fish, this loss in amphibian diversity is in part due to predation from introduced trout.

Responses and Role of WWF

The Australian national and provincial governments agreed on a Murray-Darling Initiative in 1992 and re-established the Murray Darling Basin Commission to coordinate the conservation and sustainable use of the natural resources of the basin. This included measures to cap water extraction at 1994 levels, and reduce salinity and algal blooms. In addition, since 1996, AUD $2 billion (~ USD $1.5 B) has been allocated to recover water to increase environmental flows and restore fish passage for the lower 1,800 Km of the Murray River (Australian Government 2005b; MDBC 2006). Despite these worthy initiatives, the ecological health of the rivers continues to decline.

In January 2007 the Prime Minister proposed that the Federal Government take control of the river system and spend A$ 10 billion over 10 years in an effort to reverse the river's decline. Following lobbying by WWF, the national government is finally developing a 'National Framework to Prevent and Control Invasive Species' and has developed a list of policy, coordination, prevention, early warning, rapid response, eradication and containment and control measures that should be implemented (Australian Biosecurity Group 2005). Previous national policies for weeds and feral animals focused on ineffectual 'control' programmes and ad hoc selections of species that had already escaped.

The Murray Darling Basin Commission has developed a Native Fish Management Strategy which responds to the key threats to native fish populations in the Murray-Darling basin including the introduction of alien fish species, the spread of diseases, and translocation and stocking of fish (MDBC 2003). The overall goal of this Strategy is to rehabilitate native fish communities in the basin to 60% of their estimated pre-European settlement levels, 50 years after implementation (MDBC 2003).

Authorities are experimenting with three forms of European carp control – including increasing the variability of river flows so that native fish recruitment increases and carp eggs are killed, harvesting carp for use as food, fertilizer and commercial products (including trapping carp in fish ladders), and biological control through the use of a virus known as Spring Viraemia which exists naturally in carp populations in Europe (MDBC no date).

In addition, WWF's Water for Life campaign seeks to ensure that Australia's over-allocated river and groundwater systems receive the necessary additional water to become ecologically healthy, to restore environmental flows, and to protect high conservation value systems from degradation through the National Water Initiative and National Water Commission, established in 2004 (WWF 2004a).

The most effective invasive species management is to prevent initial introduction. This needs to occur at different scales ranging from effective national quarantine programmes, to activities at the national, provincial, river basin and site scale. WWF is working with Australian government agencies to fill gaps in the national quarantine law, create a comprehensive early warning surveillance programme, and develop contingency plans to manage new incursions of aquatic pests.

5 Over-fishing

The Mekong (Asia)

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Aerial view of the Mekong delta. in Southern Vietnam.

In the Mekong, the importance of fisheries for human subsistence cannot be understated, but this naturally bountiful resource is not being managed for future use.

Clarifying fishing rights and reducing illegal fishing practices are key to preserving food security in the region.

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Mekong River's Giant Catfish being tagged and released in the Tonle Sap Lake, Cambodia.

a Mekong

i Basin Characteristics

Length: roughly 4,600 Km (Mekong River Commission (MRC) 2003)
Basin size: 805,604 Km^2 (WRI 2003)
Population: 57,197,884 people[62] (WRI 2003)
Population density: 71 people/ Km^2 (WRI 2003)
Key economic activity: fishing, aquaculture, agriculture and natural resource harvesting
Key threats: over-fishing, illegal fishing
Other threats: large infrastructure (hydropower dams - 58 large dams built and another 149 planned - and roads)[63], deforestation, changes in sediment transport patterns (linked to land use changes and built structures) and toxics from agriculture (MRC 2002 van Liere & McNeely 2005; Angell 1996)

The Mekong river basin is the largest in Southeast Asia (Milton, 2000). It is the 10th largest in the world by volume (WRI 2003), draining an area more than twice the size of Germany. Rising in the mountains of China's Qinghai province near Tibet, it flows south. It forms the border between Laos and Myanmar (Burma), most of the border between Laos and Thailand, and moves across Cambodia and southern Vietnam into a rich delta which opens to the South China Sea (WRI 2003; Water Policy International Limited 2001). Unlike many major rivers in Asia, this river and its flood regime are relatively intact (Revenga *et al.* 2000). As a result, the lower Mekong basin is the most productive river fishery in the world (MRC 2004 in WWF 2004). Freshwater fisheries here have a commercial value exceeding US$1.7 billion and provide 80% of the animal protein consumed by 55 million inhabitants (Van Zalinge *et al*.2003). Not surprisingly, the lower Mekong countries have some of the highest dependence on inland capture fisheries in the world[64] (Welcomme & Petr 2004).

The basin is home to an amazing 1,200-1,700 fish species, the highest fish diversity in any basin after the Amazon and Congo (WRI 2003). Sixty-two fish species are found nowhere else in the world (WWF 2005i). This river harbours more species of giant fish than any other on the Earth as well as the largest freshwater fish known to science, the Mekong Giant Catfish (Allan *et al.* 2005; Environmental News Service 2005). There are over 160 known amphibian species, and five Ramsar wetlands of international significance (WRI 2003). The basin is also home to the Irrawaddy Dolphin, the Mekong population of which is critically endangered (WRI 2003).

The exceptional fishery in the Mekong River is based on the ecological boost provided by the annual wet season flood of its extensive floodplain, particularly the back flow of the river into the Tonle Sap Lake in Cambodia. The scale of this beneficial flooding and consequent fish harvest is threatened by the present and potential impoundment of floodwaters behind 58 existing and 149 proposed large dams, and by roads in the floodplains.

[62] MRC estimated the total basin population to be 73 million people in 2000 and the confirmed number for the lower basin is over 55 million, so the current total population is likely much larger than this number.

[63] Ranked primary threat in the WWF Living Mekong Programme revised conservation plan.

[64] Per capita fish consumption approaches 60 Kg/ person/year (Welcomme & Petr 2004).

ii Threat of Over-fishing in the Mekong

Despite the productivity of the Mekong, the threat of over-fishing is high because of the huge scale of subsistence fishing, the majority of which goes unrecorded, as well as poor fishing practices. In basins around the world, inland fisheries are "under-reported by two to three times", so their contribution to direct human consumption is likely to be at least twice as high as the reported fish catch (Revenga *et al.* 2000). Subsistence fishing in the Mekong is heavy and destructive, and there is evidence of declining fish populations as a result. Most important however is evidence of the loss of community structure, i.e. assemblage over-fishing[65], where entire biological groups of fish, not just individual species, start to disappear.

In Cambodia's 'great lake', the Tonle Sap, where most large-scale inland fishing takes place, fishers report the rampant use of illegal fishing methods and declining fish catches (Allan *et al*.2005). Several Mekong fish species are now endangered (Allan *et al*.2005) and both the number and size of fish caught has steadily declined (FAO Newsroom September 2005). In fact, recent data demonstrates a pattern of increasing catch and increasing fishing effort followed by a declining catch with a sustained effort, typical of an over-exploited population (Allan *et al.* 2005). For instance, a century ago, the Mekong Giant Catfish was found along the entire length of the river from Vietnam to southern China. Since then, however, populations have dropped precipitously (WWF 2006b). Scientists estimate that the total number of Mekong Giant Catfish has decreased about 90 percent in just the past two decades (WWF 2006b; Environmental News Service 2005). WWF recently helped broker a voluntary ban on this species with Thai fishers (WWF 2006a). In Laos as early as 1890, a large fishery developed for the Mekong Giant Catfish but by 1940, declines were observed in northeast Thailand. Other large fish species including the River Catfish, the Giant Carp, and the Giant Stingray in the Mekong are in decline, indicating possible 'assemblage overfishing' (Allan *et al.* 2005).

In the Mekong, uncertain fishing rights, over-fishing and illegal fishing have taken a heavy toll on fish stocks. People illegally use small-meshed mosquito nets to capture fish (which catch juveniles as well as adult fish), electro-shock fish with car batteries, and increasingly over-harvest fish with poison (FAO 2005). Inherited from colonial times, the Cambodian government has managed its fisheries according to a concession system that enables unfair access, corruption and occasionally violent disputes (FAO 2005; van Zalinge *et al*. 2003).

The productivity of the Mekong River underscores the importance of this region in providing millions with food, but creates the misleading impression that its resources are limitless. It is clear, however, that unsustainable fishing practices and levels of harvest, along with changes in water flows induced by new dams, threaten the permanence of this wealth.

[65] Assemblage over-fishing occurs when fishing an area causes changes in the fish community composition, a decline in the largest-bodied species, a reduction in the mean trophic level of the assemblage, or a change in the temporal responsiveness of populations to environmental fluctuations (Allan *et al.* 2005).

Responses and Role of WWF

In 1995, all basin countries except the two upper basin states, China and Myanmar, signed the Mekong Agreement and revitalized the Mekong River Commission[66] to promote cooperative management of the river (Water Policy International Limited 2001). Though the Commission has made progress in its relations with China and Myanmar in sharing information on fisheries and hydrological data, insufficient attention has been paid to halting overfishing throughout the basin. Areas threatened by overfishing need better institutional capacity to create and enforce legislation on fishing methods and rights. In addition, community-based fishing cooperatives, improved communication between stakeholders and integrated basin management are essential in protecting beneficial flooding and the Mekong River's resources.

Sampans meet at early morning market in the Mekong delta. Vietnam.

The Mekong River Commission was involved in the Mekong Wetlands Biodiversity programme jointly implemented with UNDP-IUCN, and through the MRC Environment Programme's work on Water Quality Management (MRC 2006). Oxfam is now working with Mekong communities in Thailand to help them establish fish conservation zones, sound community fishing, and respect for local resources (Oxfam American 2005). Cambodian authorities also teamed up with the FAO and are running a participatory natural resource management programme in one of the Tonle Sap's poorest provinces, Siem Reap (FAO 2005). Currently, 5.4% of the basin's area is protected (WRI 2003). Freshwater protected areas serve as an important breeding and fish recruitment grounds, and provide as an alternative source of income for communities through eco-tourism.

The WWF Living Mekong Programme (LMP) works in Laos, Thailand, and Vietnam, and Cambodia, and with China to maintain the biological integrity and sustainable management of the basin's terrestrial and freshwater resources to benefit local communities, nations and the region as a whole. It is a multi-disciplinary project aimed at coordinating conservation and sustainable development in the river basin through a framework of strong international and regional cooperation with a wide range of key partners including the Mekong River Commission. The LMP focuses on i) effective decision-making, mechanisms and policies to reduce major threats, such as infrastructure ii) providing effective protection, restoration and management of freshwater species, habitats and ecosystem processes, iii) ensuring local populations manage their aquatic resources to contribute to sustainable regional and economic development, iv) awareness and capacity-building, and v) alternative and appropriate energy development.

[66] Mekong River Commission: http://www.mrcmekong.org/about_mekong/water_work.htm

6 Pollution

The Yangtze (Asia)

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Freight ship with coal on the Yangtze River, near the Three Gorges Dam, Hubei Province, China.

Freshwater ecosystems naturally filter and purify water. However, this ability is impaired by excessive pollution and habitat degradation *(Revenga et al. 2000).*

A number of physical, chemical, and microbial factors reduce water quality including organic pollutants, nutrients, heavy metals, salinization, acidification, suspended particles and temperature (Revenga *et al.* 2000). Rapid industrial growth has lead to devastating water pollution problems in China.

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Coal heaps on the banks of the Yangtze River, being loaded into freight ships. Hubei Province, China.

a Yangtze

Basin Characteristics

Length: 6,300 Km (People's Republic of China (PRC) 2004)
Basin size: 1,800,000 Km^2 (Owen 2001)
Population: 430 million people by the end of 2003 (National Bureau of Statistics 2004)
Population density: 238 people/ Km^2(National Bureau of Statistics 2004)
Key economic activity: agriculture, industry, transportation
Key threat: pollution (sedimentation, and industrial, agricultural and domestic waste)
Other threats: 105 large dams planned or under construction, inter-basin water transfer and other water infrastructure, over-fishing and illegal fishing (WWF 2004)

The Yangtze River, also called the Chang Jiang meaning 'long river', rises in the mountains of Qinghai Province on the Tibetan plateau, and flows 6,300 Km to the East China Sea, opening at Shanghai. Its catchment covers 1/5 of the land area in China (PRC 2004). For two centuries, the Yangtze has served as a transportation and commercial thoroughfare, and steamers can navigate as far as Yichang, 1,600 Km from the sea (Owen 2001). The Yangtze river basin accounts for 40% of China's freshwater resources, more than 70% of the country's rice production, 50% of its grain, more than 70% of fishery production, and 40% of the China's GDP (National Bureau of Statistics 2004).

In addition to its social and economic importance, the Yangtze river basin is a centre of immense biological wealth. The river is home to 350 fish species (including the giant Yangtze Sturgeon), of which 112 are endemic (Park *et al.* 2003). In the main channel of the upper Yangtze alone, there are 261 fish species, 44 of which are found only in this region (Park *et al.* 2003). The Yangtze contains high crab biodiversity, and over 160 amphibian species (Grommbridge & Jenkins 1998). This basin is the sole habitat of the critically endangered Chinese Paddlefish, the endangered Finless Porpoise, and the now believed to be extinct Chinese River Dolphin, the most critically endangered cetacean in the world (WWF 2005h). The most threatened crocodilian species in the world, the Chinese Alligator, is only found in the lower reaches of the Yangtze[67] (WWF 2005h). This basin is home to other endangered charismatic species including the Giant Panda, the largest salamander in the world, *Audrias davidianus*, the once-extirpated Pere David's Deer now re-introduced from captive stock, and the critically endangered Siberian Crane (WWF 2005h; WWF 2004).

[67] More than 2,000 individuals exist, but most are artificially bred.

ii Threat of Pollution in the Yangtze

Rivaling the impact of the Three Gorges Dam, this basin faces unprecedented pollution as a result of rapid, large-scale industrial and domestic development, and agricultural runoff. According to Chinese environmental activist Dai Qing, the Yangtze used to be so clear that you could see a pen sink to the bottom. Now it has become so dirty that it is not fit for drinking (Chao 2006). Over the last 50 years, there has been a 73% increase in pollution levels from hundreds of cities, in the main stem of the Yangtze River (WWF 2005h). The annual discharge of sewage and industrial waste in the river has reached about 25 billion tons, which is 42% of the country's total sewage discharge, and 45% of its total industrial discharge (WWF 2005h; Fang and Zhou 1999 in Pu 2003). In addition, the CCICED (China Council for International Cooperation on Environment and Development) Task Force on Reducing Non-Point Pollution from Crop Production concluded that 92% of the nitrogen discharged into the Yangtze is from agriculture (CCICED 2004). Shipping discharges are also to blame for the river's declining health (Reuters 2006). As well, the extensive loss of floodplain areas to agriculture has reduced the basin's ability to detoxify pollutants.

The major pollutants in the Yangtze mainstem are suspended substances, oxidizing organic and inorganic compounds, and ammonia nitrogen (Pu 2003). This has severely reduced drinking water quality and contributed to dramatic eutrophication (WWF 2005h). In addition, shallow, slower water flowing in belts adjacent to the banks near urban areas, and in smaller lakes and tributaries off the main stem, suffer even worse eutrophication and higher concentrations of the pollutants (Pu 2003; Anid & Tschirley 1998). In one study, cadmium levels in irrigation waters at Hubei Province in the middle reaches of the Yangtze were 160 times applicable water standards (Anid & Tschirley 1998). Tests from the hair of affected populations revealed that the levels of cadmium are five times higher than background levels and only marginally lower than the threshold concentration causing itai-itai disease in humans (Anid & Tschirley 1998). Local Chinese experts are now describing pollution in the Yangtze as 'cancerous' (Reuters 2006).

In addition, the Yangtze is the fourth largest sediment carrier in the world due to the proportion of arable land in its catchment, damming and erosion from land conversion (farming and forestry)[68] (Higgitt & Lu 1999; Owen 2001; Li & Deng 2004). In the first sixty years of the 20th century, the Yangtze's sediment yield increased by about 30%, which corresponds to a related increase in surface erosion area in the basin (Yang *et al.* 2004). Since the 1960's, the sediment yield in many areas of the basin has increased, while the suspended sediment flux has dramatically decreased as it has been trapped in dam reservoirs (Yang *et al*. 2003).

Lastly, hydropower developments impound reservoirs that severely affect water quality. After 13 years of construction, the Three Gorges Dam is now built and will be fully operational in 2008 (Chao 2006). The Three Gorges Dam[69] exacerbates water pollution by impounding waters, trapping sediment and increasing eutrophication. Chongqing Municipality, at the confluence of the Yangtze and Jialing rivers has become the largest economic centre in southwest China, but is the largest source of organic water pollution in the Yangtze upstream of the Three Gorges Dam (World Bank 1998). Before the Three Gorges Dam, health impacts in the area were already substantial including intestinal infectious diseases such as hepatitis A, and dysentery incidence rates some 50% higher than the national average. *E.coli* bacteria is rampant in water sources, and as high as 15,000 *E.coli*/L in some parts of the city (World Bank 1998). The Three Gorges Dam, about 660 Km downstream, reduces the velocity of the Yangtze River, increases its water depth, and alters the natural flow regime. In the huge reservoir[70] behind the dam, eutrophication threatens surface water quality, and near water intakes (World Bank 1998; IRN 2001). Also, impounded water submerges existing urban water and sanitation infrastructure. In addition, construction for the Three Gorges Dam never included a budget to clean towns of toxic waste before submerging them (Chao 2006). In Wanxian, Wan County, the Three Gorges Dam submerges part of the sewer system and waste water treatment plant as well as dumpsites along the river (World Bank 1998). Garbage heaps, boat effluent, pig and animal waste, factories, hospitals, and mines containing hazardous and possibly radioactive waste on the bottom of the reservoir are creating serious pollution (Owen 2001; China's State Environmental Protection Administration (SEPA) 1997 in Owen 2001; WWF 2005h; Chao 2006). In addition, possible riverbank collapses and landslides[71] as a result of damming will add even more stress to the water quality of the Yangtze (Jian *et al*. 2005).

[68] Between 1950 and 1998, there was a loss of more than 50% of both marsh and forest area along the Yangtze (US Embassy to China 1999).

[69] The Three Gorges Dam plans make it wide enough to block the Golden Gate Bridge (IRN 2001).

[70] 185m deep and more than 600 Km long in the main channel of the Upper Yangtze (Owen 2001).

[71] Predicted destructive and disastrous over an area less than 5% of the fore-reservoir region, 20 Km from the Three Gorges Dam (Wu *et al.* 2001).

Responses and Role of WWF

Efforts to reduce pollution in the Yangtze River have been slow but promising. Community pressure has successfully increased local enforcement activities such as field inspections and increased pollution fees. China's pollution fee system was introduced in the early 1980s to control pollution and create an incentive for corporate investment in control projects (Pu 2003). Market reform has been an important factor in motivating industry environmental performance (Dasgupta *et al.* 1997 in Pu 2003). In fact, market reform and community pressure have generated as great an impact on industrial pollution as direct regulation and the charge-subsidy system (Pu 2003).

Fishing is a main livelihood on Zhangdu, site of consevation work supported by the WWF HSBC Yangtze Programme, Hubei Province, China.

In the past year, Chinese government authorities, with support from WWF, have taken steps toward developing an integrated basin management plan which would help stem the threat of pollution in the Yangtze. Integrated river basin management (IRBM) is vital to enable communities to restore the natural capacity of their watershed to 'treat' pollution. IRBM is a tool communities can use to balance development and conservation needs, such as whether to construct dams or diversions, which severely affect quality of water in a basin.

Conceived by WWF with the Chinese government, the Yangtze Forum was held in Wuhan from April 16-17, 2005 and marked the first time that so many major stakeholders convened to discuss a blueprint for the Yangtze basin's development and conservation crossing administrative and sectoral boundaries. Four key national government authorities, four river basin authorities, 11 provincial governments along the main stem, three academic organizations, and 200 people from 14 countries participated. Participants agreed on a joint statement of shared priorities and goals, the Yangtze Declaration on Protection and Development, which calls for the revision and updating of the Master Plan for Comprehensive Utilization of the Yangtze river basin, and the addition of ecosystem health as a key target.

Restoration of floodplain wetlands in the central Yangtze region has been a focus of WWF's field work to restore wildlife habitats, reduce flood risks, and improve livelihoods of local people (Schuyt 2005). Since 2002, the connections between 11 lakes (including Hong Lake, Zhangdu Lake, Baidang Lake, and Tian-e-zhou Oxbow) and the Yangtze River, for example, are being restored through the WWF-HSBC Yangtze Programme. WWF is supporting and demonstrating new sustainable agricultural practices such as organic farming and eco-fishery to reduce agricultural pollution in the Dongting Lake and Hubei Province.

Conclusion

There are enormous threats to the integrity of the world's great river basins, the sources of drinking water, the basis of our economies, and the fabric of our communities. WWF proposes the following solutions to the six primary threats faced by the ten most endangered river basins. Given the range of threats, there are many ways in which to protect river basins. Stakeholders in each basin can prioritize these solutions and implement them through ***integrated river basin management***.

1 Over-extraction

*Over-extraction of water for agriculture and domestic consumption threaten to make the **Rio Grande** and **Ganges** Rivers run completely dry.*

Solutions: Establishing environmental flows, improving water allocations and rights, improving efficiency in water use, instituting payments for water services, switching to production of less thirsty crops, removing agricultural subsidies that encourage excessive water extraction, and developing a network of partnerships that promote sustainable development are critical.

2 Dams and infrastructure

*Dam and infrastructure projects threaten freshwater habitats in the **Salween**, **La Plata**, and **Danube** basins.*

Solutions: Assessing whether new infrastructure is the best means of delivering the required service is the first step (for example, in the Danube, rail transport may be a better option). If infrastructure is the best option it should be planned to minimize impacts by: siting off the river's main stem and floodplains, mimicking natural water flows, allowing fish passage, controlling thermal pollution, and maintaining sediment and nutrient flows critical to sustaining the health of the rivers. Effective treaties between riparian nations to support integrated river basin management are essential for good governance.

3 Invasive species

*Invasive species threaten the ecology of the **Murray-Darling** basin.*

Solutions: Preventing the introduction of new invasive species through better laws and programmes for quarantine, risk assessments of 'sleeper' exotic species, incursion management and vector control are essential. The aquarium and aquaculture trades are two important vectors to focus on. Enhanced public education and awareness can limit the spread of aquatic invasive species. Control of escaped exotic species is a second best option but can be partially effective through reducing reproduction using various methods.

4 Climate change

*Higher temperatures associated with climate change threaten to plunge the **Indus** basin into further water scarcity due to its dependence on melt waters from declining Himalayan glaciers. Higher temperatures also have potentially devastating consequences for fishery productivity, water supply and political security in Africa's arid **Nile-Lake Victoria** basin.*

Solutions: International cooperation, technology transfer, and awareness are crucial to reduce greenhouse gas emissions and adapt to climate change. Improving the resilience of forest watersheds, rivers, lakes and other wetlands by protecting key latitudinal and altitudinal corridors to facilitate species migration, and boost ecosystem health may also attenuate some of the impacts of climate change on biological diversity.

5 Over-fishing

*In the **Mekong**, inappropriate fishing practices, inadequate distribution of fishing rights and the high level of fish consumption have led to destructive levels of fishing.*

Solutions: Clarifying fishing rights, increasing local capacity to manage aquatic resources, and stronger regulation and enforcement of illegal fishing practices can stem the threat of over-fishing. Conservation and restoration of habitats. Maintenance of adequate environmental flows is essential.

Overall, integrated river basin management (IRBM) with diverse stakeholder engagement and effective watershed management authorities, is essential to the sustainable use of river basin resources. In this way, diverse interests including fishers, farmers, government agencies, and environmental groups create long-lasting partnerships which are essential in developing a common vision and solutions for sustainable natural resource use and conservation in a basin. IRBM allows communities to manage river basins from 'source to sea', in accordance with the 'ecosystem approach' that member governments have committed to through the CBD and also the Ramsar Convention on Wetlands (Ramsar Convention on Wetlands 1999).

6 Pollution

*In the **Yangtze** basin, decades of heavy industrialization, damming, and huge influxes of sediment from land conversion have made it one of the most polluted rivers in the world.*

Solutions:
It is essential to value the cost to human and wildlife health when calculating the economic feasibility of proposed development. Protecting watersheds and wetlands from deforestation, conversion and damming can reduce erosion and sedimentation, and help purify water of toxic chemicals. Pollution can be curbed through better management practices for production of crops and livestock, improved enforcement of pollution laws, fees and tradable rights, innovative payment for ecosystem service schemes, and the adoption of comprehensive integrated river basin management plans.

The world's top ten rivers at risk identified by WWF highlight the reasons for the catastrophic loss of freshwater biodiversity, the wanton waste of freshwater resources, poor governance, and a disregard for the needs of local people that frequently exacerbates poverty. However, in these tales of destruction lie indicators of the solutions that can enable the conservation and restoration of the world's great rivers. No solution will be effective in any of these river basins unless it is implemented through cooperation across social, economic, and political boundaries. Only then can the people of the world's great basins rest easy, when the river again knows exactly where it is going, and it is sure to get there.

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The mission of WWF is to stop the degradation of the planet's natural environment and to build a future in which humans live in harmony with nature, by:

- conserving the world's biological diversity
- ensuring that the use of renewable resources is sustainable
- reducing pollution and wasteful consumption

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