Water for life:
Lessons for climate change adaptation from better management of rivers for people and nature

Jamie Pittock

This report presents six cases where the work of WWF and its partners has resulted in adaptations in water management that are reducing vulnerability to expected climate change impacts, and are also improving the livelihoods of local people and enhancing the conservation of freshwater biodiversity.

The six cases are:

1. Lower Danube in eastern Europe;
2. Great Ruaha River in Tanzania;
3. Maner River, a tributary of the Godavari River in India;
4. Lakes in the central Yangtze River basin of China;
5. Rio Conchos in Mexico; and
6. Rio São João in Brazil.

Cover: Dry river channel, lower Danube basin. © Anton Vorauer / WWF-Canon.
This spread: Children playing in a channel, Ruaha basin, Tanzania. © Brent Stirton / Getty Images / WWF-UK.

THE ADAPTATIONS UNDERTAKEN

These six cases of adaptation were not explicitly designed to address the full impacts of climate change on these basins. High confidence climate change scenarios are not available for these river basins that would enable managers to adopt specific counter measures. Yet in each case there was knowledge of historical extremes that enabled "auto-adaptation" to manage in increasing uncertainty the impacts of floods and droughts, water scarcity and pollution.

The work of these projects involved social and institutional changes as much or more than biophysical and technological interventions to reduce vulnerability to the likely impacts of climate change. The adaptation tools and measures deployed included:

1. Decommissioning or changing the operations of under-performing infrastructure, like flood "protection" dykes and sluice gates;
2. Restoring the ability of the natural environment to provide ecosystem services, such as floodwater retention, storing water in aquifers, water purification and fisheries;
3. Adopting locally available and small-scale technologies, such as village water tanks;
4. Changing agricultural and aquacultural practices to more sustainable methods that: produce fewer pollutants; reuse water, such as for fish production then irrigation are more water efficient; require less inputs and secure higher returns for more valued produce;
5. Providing better waste management systems, especially for sewerage;
6. Diversifying local livelihoods into less water dependant enterprises;
7. Increasing the incomes derived from natural commodities, like fish, to reward producers adopting more sustainable practices and increase the resilience of these households;
8. Establishing and strengthening local institutions to facilitate adaptive management and self-determination, including establishing and enforcing more sustainable behavioural norms for uses of natural resources like water;
9. Facilitating basin-scale multi-stakeholder institutions to: establish partnerships; develop common visions; lead adaptive management; and connect the local to global measures needed for more effective adaption and sustainability;
10. Advocating for laws and government programs that facilitate subsidiarity, by providing basin and local institutions with the mandate and access to resources for adaptive management;
11. Improving connectivity in freshwater ecosystems by applying environmental flows, ensuring wildlife passage through or over water infrastructure, and restoring riparian habitats; and
12. Restoring habitats to increase the resilience of these ecosystems to climatic impacts and their capacities to support greater populations of flora and fauna species, especially those that are threatened or of economic value.

Table 1 (on page 7) summarises the main adaptation, livelihood and conservation benefits by project.

THE ADAPTATION OUTCOMES

The freshwater adaptation outcomes can be categorised as enhanced:

1. **Flood retention** – increased capacity to safely retain higher peak flood flows;
2. **Water security** – more reliable access to water in areas prone to scarcity;
3. **Pollution reduction** – cuts to pollution levels and the risk that pollution impacts like eutrophication will be exacerbated by higher temperatures;
4. **Livelihoods** – diversified income generation strategies and increased incomes of many participants that may increase resilience of communities to climatic events;
5. **Institutional capacity** – established and strengthened local institutions, increasing their adaptive management capacities;
6. **Connectivity** – re-linked habitats and populations of species, enabling greater mobility and capacity to colonise new habitats that may be required to survive in a warmer world; and
7. **Populations and habitats** – restored populations of species and areas of habitat that may better resist and survive impacts of severe climatic events.

Left: Restored Lake Hong, China. © Claire Doole / WWF-Canon.
Right: Fishing on restored lake, Zhangdu. © Yifei Zhang / WWF-Canon.

THE LESSONS LEARNT

These cases are historical examples from which we have derived higher-level lessons on how to help societies adapt to the commonly expected impacts of climate change on rivers and water resources. From the six cases presented in this report, the lessons derived are:

1. **Multiple benefits –** many freshwater adaptations to climate change impacts are practical now, can be scaled up, and may have benefits for peoples' livelihoods and for nature conservation – they are "no regrets" measures;
2. **Communicating adaptation –** better communication is required to inform and encourage local communities and governments, to overcome the perception of adaptation as a complicated process requiring new expertise to succeed;
3. **Local ownership –** participation of local stakeholders in the design, implementation, and management of adaptation creates new societal norms that ensures the sustainability and effectiveness of the measures;
4. **Immediate benefits –** local stakeholder support depends on receipt of immediate benefits, which may then engender support for more challenging measures;
5. **Adaptive management –** adaptation is an iterative process requiring mainstream institutions to engage relevant stakeholders to work on and revise key measures over many years. River basin management organisations are key adaptation institutions in most societies;
6. **Linking local to national to global –** the most effective adaptations draw strength and link action at different geo-political scales. Sub-national governments were enthusiastic partners in these adaptation efforts, apparently motivated by vulnerability reduction and sustainable development opportunities. National laws and resource provision that support basin and sub-basin scale institutions appear vital for adaptive management of freshwaters. Basin and multi-lateral treaties are a catalyst for better river management in transboundary situations;
7. **Post disaster reform –** there is great impetus for adaptation following major natural disasters or severe environmental degradation that should be seized; and
8. **Funding adaptation –** the social, institutional and environmental-focused adaptations studied had a modest cost and were cheaper than identified impacts or alternative adaptations (such as large infrastructure projects). Upfront investment was required for necessary infrastructure, seed capital or loans, and to pay transition costs. The initial adaptation funding came from non-government organisations, development banks and other aid donors. National governments often contributed funding only after the adaptations had shown the potential to succeed.

DISCUSSION OF KEY ISSUES

The freshwater projects studied here are from sites where aquatic environments had been extensively degraded through desiccation, pollution and land use change. Consequent restoration of these sites suggests that practical and affordable adaptations of freshwater management can reduce vulnerabilities to climate change, and in many instances, also provide benefits for peoples' livelihoods and conservation of freshwater habitats. Two questions arise from these examples of generic adaptations: a) could more targeted and sophisticated programs achieve more, and b) could the resilience building adaptations implemented in these projects be overwhelmed as climate change impacts exceed key thresholds?

There is little doubt that more climate informed and target driven projects could achieve more effective adaptation, for example by better defining the freshwater biodiversity conservation objectives and the thresholds for the quantity and quality of water required to achieve them. In the Ruaha and Rio Conchos projects, the generic adaptations implemented on water scarcity are buying time and stakeholder ownership for the development of scientifically-based, quantitative environmental flows. This suggests that starting action to adapt to the most obvious problems should not wait for more precise information.

By contrast, in the Yangtze and Danube, the floodwater retention capacities achieved by the restoration of floodplain sites are known and appear part of larger governmental decisions on the levels of acceptable flood risk.

If climate change impacts become more severe there is a risk that the adaptations to manage water scarcity and quality, documented in these projects, could be insufficient to meet the needs of people and the environment. Yet these resilience building measures have engaged and built the capacities of local institutions in adaptive management process that may provide the social and institutional resources needed to address greater climate impacts. These adaptations have bought time to consider whether more radical measures are required. By contrast, the increase in flood water retention capacity achieved in these projects will always be valuable. All of these adaptations have two prized qualities: they are "no regrets" measures, and they can be scaled up considerably to substantially increase resilience at a basin or greater scales.

Left: Floodplain forest, lower Danube. © Michel Gunther / WWF-Canon.
Right: Bore well, Maner basin, India. © Jamie Pittock / WWF-Canon.

Left: Fishing on restored lakes, Lake Hong. © Yifei Zhang / WWF China.
Right: Fishing on restored lakes, Zhangdu. © Anton Vorauer / WWF-Canon.

While WWF and local institutions did not conceive these projects for comprehensive climate change adaptation, this varied from those explicitly addressing floods as a climate impact, to projects that had not thought of adaptation until it was raised by this study. The staff of WWF and their local institutional partners, that include people highly educated in relevant fields, had not focused on climate change adaptation. If these sorts of local thought leaders had not fully engaged in adaptation, why not? What would mobilise more regional societies to mainstream adaptation?

A common response of the local project staff when approached to participate in this research was that insufficient climate change impact data was available for their river basin to enable development of targeted adaptation responses. This suggests that awareness of climate change adaptation methods was low. Climate change adaptation proponents need to consider whether a mystique surrounding the data, methods and expertise required for effective adaptation is a barrier to implementation. In the Danube and Rio Conchos, however, some consideration of climate change was evident. Staff in all the projects were focused on reversing the severe environmental degradation evident in these basins. In a number of the projects, as a result of participating in this research, the project staff have responded with renewed confidence that the adaptations they are implementing can be enhanced and become better climate-informed. This suggests that there are many local institutions that if directly engaged will consider climate change adaptation. It is also clear that many local people and institutions implemented these measures more for the short term livelihood and development benefits than reduction of long term risks. Proponents need to link adaptations to outcomes of value to local communities.

This research shows that adaptation is best considered as a pathway that starts by implementing the "no regrets" measures to address obvious vulnerabilities that most societies can undertake with locally available knowledge and technologies, often with a little external help. The small-scale but increasingly widespread local measures outlined in this report add up to substantial adaptation and buy time to consider and gather the resources needed if progressively harder adaptations are required. A number of these case studies exhibit a virtuous cycle where initial, successful interventions have generated stakeholder support and built capacities for progressively more sophisticated measures that will further enhance adaptation to climate change.

This report shows that practical adaptations to climate change impacts on freshwaters may have immediate benefits for peoples' livelihoods and to conserve ecosystems, and should be priorities for governments and aid donors.

Table 1 Summary of key adaptation, livelihood and conservation benefits

Project	Likely major climate change impacts	Key adaptation benefits	Key livelihood benefits	Key ecosystem benefits
Lower Danube, eastern Europe	Flooding increased. Pollution exacerbated. Biodiversity impacted.	Flood storage increased through restoration of floodplains. Plan to restore 2,250 km^2. 14.4% has been or is being restored. Pollution reduced.	Livelihoods diversified. Better access to clean water. Ecological services of €500/ha from restored floodplains.	Restored 4,430 ha of habitats and reconnected a 68 km^2 lake to the river. Fish and bird populations restored. Protected areas expanded by 5,757 km^2 in Romania.
Great Ruaha River, Tanzania	Greater water scarcity. Biodiversity impacted.	Reduced vulnerability to drought. Water Users' Associations and other basin institutions strengthened.	Established 20 Community Banks. Diversified into livelihoods with reduced reliance on water.	Flows restored in some places. Water sources and riparian vegetation restored. Tree felling for charcoal production reduced.
Godavari tanks, India	Greater water scarcity. Impacts of alternative adaptation options.	Greater surface and ground water access from restored tanks. Tank management systems established. Program adopted by the state government. Alternative to proposed US$4 billion dam demonstrated.	Increased agricultural production, employment and incomes. Reduced agricultural inputs. Cultural benefits.	Enhanced habitats for birds in the tanks. Alternative to environmental damage from proposed new dam demonstrated.
Yangtze lakes, China	Flooding increased. Pollution exacerbated. Biodiversity impacted.	Restored 450 km^2 lakes. Can retain 285 Mm^3 of flood waters. Reduced pollution. Government adopted restoration policies. Yangtze Forum established for adaptive management.	Improved access to drinking water. Fish resources increased. Diversification of livelihoods and increased incomes.	Restored 450 km^2 lake habitats, new 60 km^2 reserve. Populations of fish, birds and Yangtze Porpoise increased.
Rio Conchos, Mexico	Greater water scarcity. Biodiversity impacted.	Vulnerability to drought reduced. Established institution for adaptive basin management. Environment recognised as a user in the water law.	More secure access to water. Increased economic efficiency in agriculture. Enhanced livelihoods of communities in the headwaters.	Conservation of endemic fish. Developing payment for ecological services and environmental flows.
Rio São João, Brazil	Pollution exacerbated. Biodiversity impacted.	Pollution cut by 75%. Establishment of multi-stakeholder, adaptive, river basin management institutions. Management approach adopted nationally.	Restored 244 km^2 coastal lagoons rejuvenating tourism and fishing industries Training and economic diversification. Improved water supply.	Restored riparian, floodplain and lagoon habitats. Riparian corridors link remnant habitat of the threatened Golden Lion Tamarin. River connectivity restoration planned.

LOWER DANUBE IN EASTERN EUROPE

Healthy floodplain habitat, Danube
© Michele Depraz / WWF-Canon

Context

Along the lower Danube River, where more frequent flooding is anticipated with climate change, the restoration of floodplains is providing room to retain and safely release floodwaters. In 2000 WWF secured agreement from Bulgaria, Romania, Moldova and Ukraine to restore 2,236 km^2 of floodplain to form a 9,000 km^2 "Lower Danube Green Corridor." Cut-off from the river by dykes, these floodplain lands are currently of marginal value for primary industries, and once restored, will be of similar scale as the area inundated in the 2005 and 2006 floods.

Intervention

As of 2008, 469 km^2 of floodplain has been or is undergoing restoration, enhancing local peoples' livelihoods and nature conservation.

Impacts and benefits

Each hectare of restored floodplain is estimated to provide €500 per year in ecosystem services, helping to diversify the livelihoods of local peoples. Restoration of the 37 sites that make up the Lower Danube Green Corridor is estimated to cost €183 million, compared to damages of €396 million from the 2005 flood and likely earnings of €85.6 million per year.

Lessons

This large-scale adaptation shows the value of restoring the natural resilience of the environment to climate events by decommissioning under-performing water infrastructure, in this case by more safely retaining and releasing peak floods. It also highlights how replacing vulnerable monocultures with more diverse livelihoods based on natural ecosystems (in this case tourism, fishing, grazing and fibre production) can strengthen local economies. International agreements for better water and river management have been a powerful driver of change in the Danube.

Left: Fishing in the lower Danube. © Anton Vorauer / WWF-Canon.
Right: Eutrophication of a Danube side-channel, Hungary. © Michèle Dépraz / WWF-Canon.

Danube Basin
Rivers

GREAT RUAHA RIVER IN TANZANIA

Water management planning in the field, Ruaha, Tanzania. © Brent Stirton / Getty images / WWF-UK.

Context

Waterways in the headwaters of the Great Ruaha River dried up in the dry season from the early 1990s, severely impacting on both people and biodiversity. Greater water scarcity is feared with climate change.

Intervention

WWF intervened to establish local Water Users' Associations, and assist them to restore native vegetation in the catchments, protect the river banks, better manage water extractions, and enforce water rules.

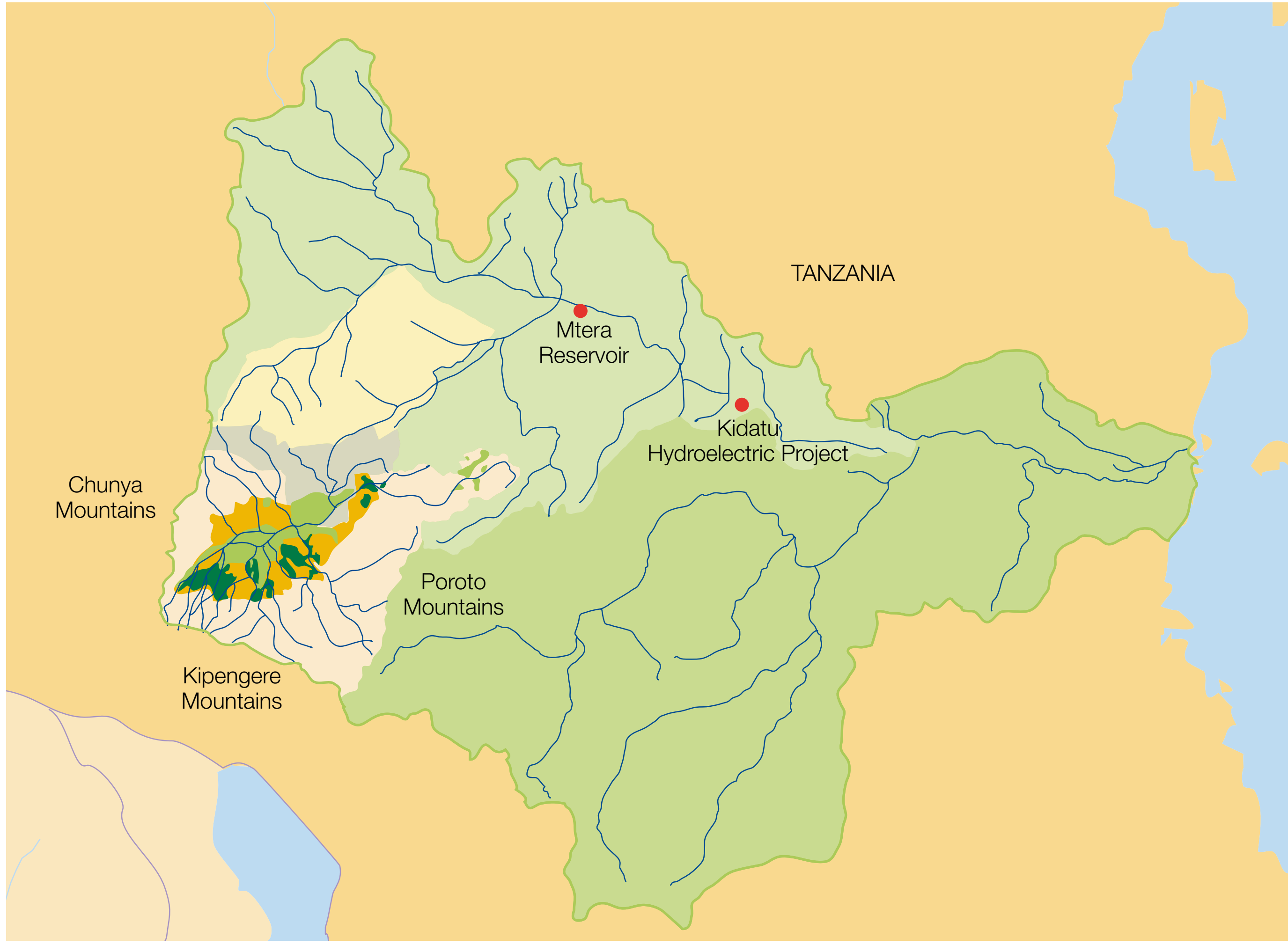
Impacts and benefits

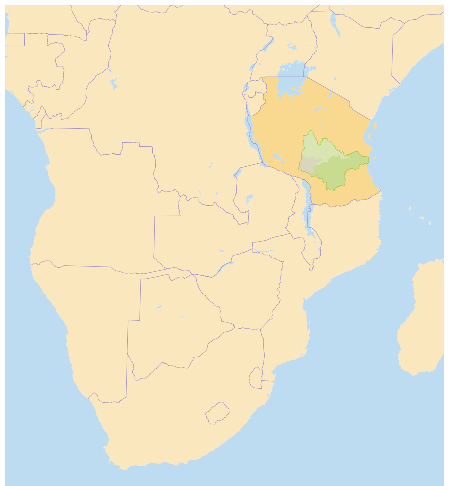
Simple changes in local agricultural and natural resource use practices, such as better scheduling of water diversions, have made significant differences. This has restored flows in many streams and parts of the Great Ruaha River itself, and now a more rigorous environmental flow assessment is underway. Establishment of 20 Community Conservation Banks has also reduced the reliance of many local people on water related primary industries by facilitating diversification of the local economy and increasing their incomes.

Lessons

These inexpensive, grass roots adaptation measures demonstrate how incremental action to restore ecosystem functions and better manage natural resources can increase resilience to climate change. It highlights the importance of strengthening the capacities of local people and organisations to improve governance, diversify the local economy and institute adaptive management practices. This case also emphasises the need for governments to support local organisations with appropriate mandates and financial independence to undertake ongoing adaptive management.

Left: Ruaha River, Tanzania. © Brent Stirton / Getty images / WWF-UK.
Right: Water management planning, Ruaha, Tanzania. © Brent Stirton / Getty images / WWF-UK.





- Rufiji Basin
- Great Ruaha River Catchment
- Usangu area
- Ruaha National Park
- Usangu Game Reserve
- Wetlands
- Irrigation
- Rivers

MANER RIVER, A TRIBUTARY OF THE GODAVARI RIVER IN INDIA

Desiccated Maner River, India.

Context

In peninsula India, the year's rain often falls in only 100 hours during the monsoon, making its storage essential for year-round use. Growing populations and over-exploitation of surface and groundwater supplies threatens the livelihoods of millions of poor farmers, a threat exacerbated by the potential for more droughts and intense rainfall with climate change.

Intervention

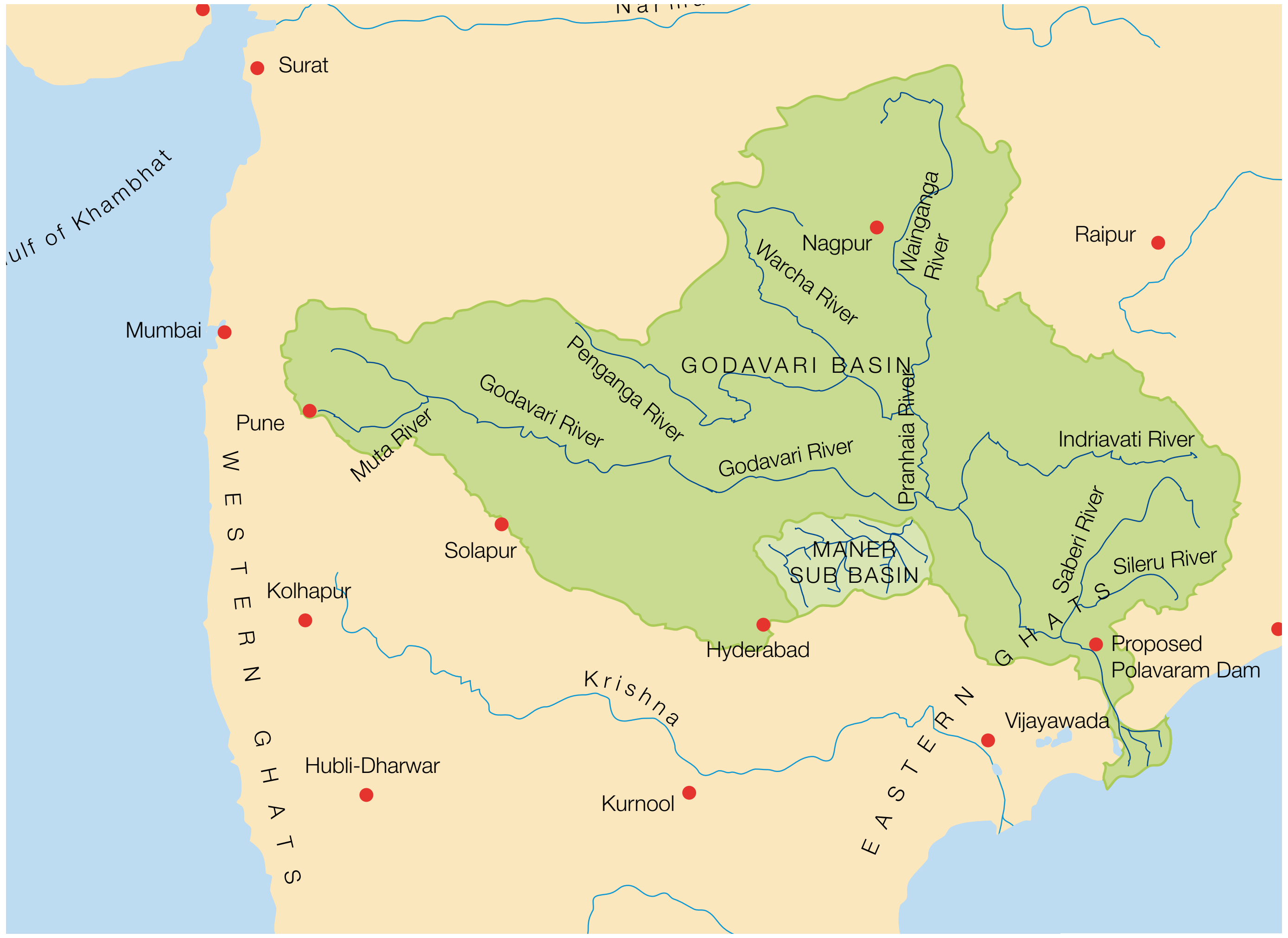
WWF intervened with a pilot project to restore 1,200 year old village water tank systems — modest earthen dams — in the Godavari River basin. In the Maner River basin, 12 tanks serving villages of 42,000 people were restored for US$103,000 in cash and kind.

Impacts and benefits

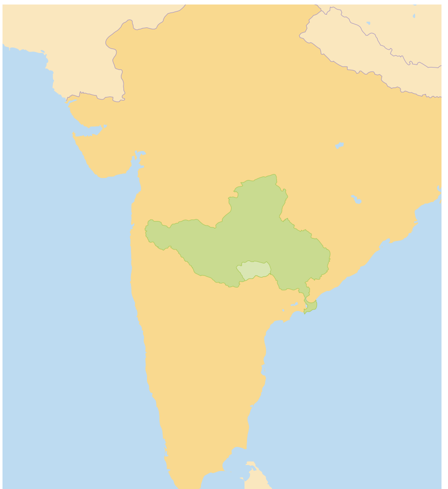
Security of water access increased, including from greater recharge of local aquifers. Agricultural production and profitability increased from: better access to water; soils enhanced with silt from the tanks; and reduced input costs. Local employment increased and tank committees were established by each village to manage its water supply. WWF calculates that de-silting all the village tanks in the Maner River catchment at a cost of US$635 million could increase water storage capacity to a similar extent as the proposed Polavaram Dam on the Godavari River. While the dam may refill more than once per year, this maladaptation would cost US$4 billion, displace 250,000 people, and inundate key habitats, including 60,000 hectares of forest.

Lessons

This project also shows how building community capacities, applying technologies that are locally available, and undertaking small-scale measures could add up to effective and inexpensive large-scale and pro-poor adaptation. This contrasts sharply with the negative consequences of the inflexible, large infrastructure alternative, namely: cost; constraints on scaling up implementation; displacement of people; limited capacity for village self-determination; fewer benefits for the poor; and substantial environmental impact.



Left & Right: Restored village water tanks, Maner basin, India.



External boundaries of India as depicted are neither correct nor authenticated.

Godavari Basin
Maner Sub Basin
River Network

LAKES IN THE CENTRAL YANGTZE RIVER BASIN OF CHINA

Restored Lake Hong, China © Yifei Zhang / WWF China.

Context

Floods are common on the Yangtze River, but these have become more severe since the 1990s. Further, the extensive discharge of pollutants into the river system has resulted in cases of eutrophication. Both problems are expected to be exacerbated by climate change. Hundreds of lakes cut-off from the river by dykes have become polluted and aggravated flood peaks.

Intervention

At three sites WWF intervened to promote replacement of polluting aquacultural and agricultural practices and opening sluice gates to reconnect lakes to the river, dramatically improved water quality.

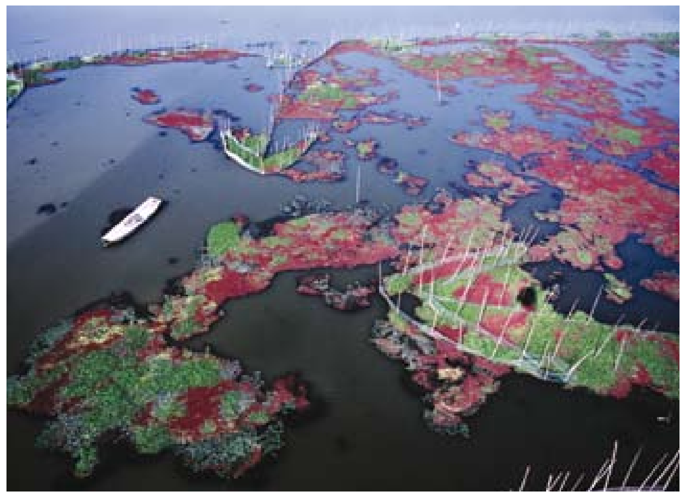
Impacts and benefits

Following adoption of these measures at a fourth lake, the 448 km² reconnected area can now safely retain 285 Mm³ of flood waters. Fisheries have increased production by around 15% and are now sustainable. More lucrative, diverse and sustainable livelihoods for local people make the economy less vulnerable to climate impacts. Habitat for threatened wildlife and populations of species has been restored and conserved, increasing their resilience to climatic events. Provincial and national government agencies are now supporting these changed management practices more widely.

Lessons

This case also shows the value of restoring the natural resilience of the environment to climate events, in this case by restoring connectivity between the river and lakes by improving operations of under-performing water infrastructure. Assisting the local community to adapt their aquaculture and agriculture to more sustainable practices has enhanced their livelihoods and the environment. Working in partnership with government agencies has ensured that these changed practices are now mainstreamed in daily operations, and has seen these measures adopted at other lakes.

Yangtze Basin
Rivers



Left: Eutrophication (pollution) and fishing nets before restoration, Lake Hong, China. © / Yifei Zhang / WWF China.
Right: Harvesting food from restored Lake Hong. © / Yifei Zhang / WWF China.

RIO CONCHOS
IN MEXICO

Context

In the Rio Conchos basin the 1994–2006 drought threatened farmers and endemic fish species alike, and placed Mexico in arrears in its treaty obligations to deliver water to the Rio Bravo/Grande. Extended drought is a likely consequence of climate change in this region.

Intervention

WWF intervened to promote integrated river basin management and more efficient water use. The large initial investment in surface water efficiency proved to be a maladaptation as it reduced aquifer recharge, and coupled with the lack of adequate measures to manage groundwater, saw a further decline in water availability. A renewed program for more sustainable, conjunctive management of ground and surface waters is now conserving water, cutting demand at Delicias from 943 Hm^3 per year by 200 Hm^3.

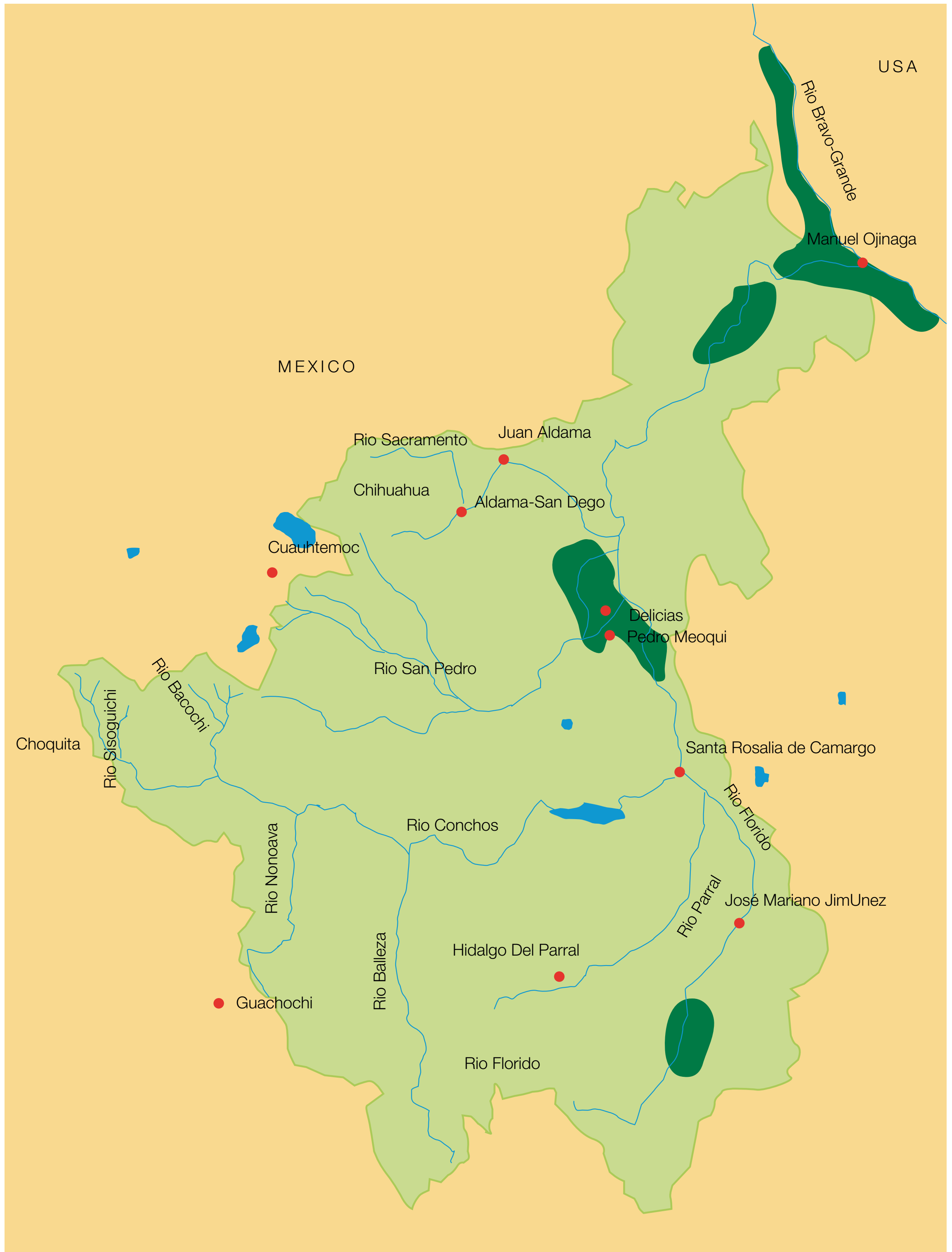
Impacts and benefits

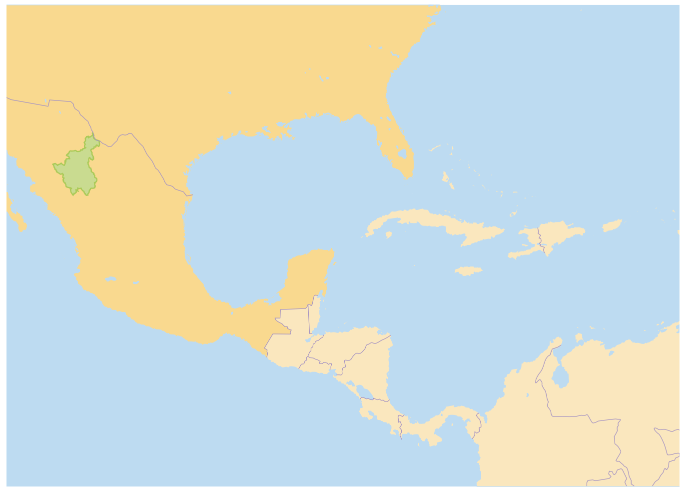
This initial work has bought time and established partnerships needed to more precisely determine the environmental flows needed to sustain the health of the Rio Conchos's ecosystems. The water volume required is less than needs to be delivered under the treaty with the USA, so there is a good prospect of implementing these flows. The establishment of the multi-stakeholder Inter-institutional Working Group is now facilitating these types of adaptive management measures in the basin.

Lessons

The essential need for conjunctive management of surface and ground waters is an important adaptation lesson from the Rio Conchos. The project also highlights how it is possible to reduce demand for water and vulnerability to water scarcity. Acting now to attenuate the most obvious impacts while developing more sophisticated and precise measures, as shown with environmental flows, is a key feature of adaptation in this example. The Rio Conchos also demonstrates the value of multi-stakeholder institutions and international agreements in facilitating and driving adaptive management.

Left: Inefficient irrigation requires more water. © David Lauer Read / WWF.
Right: Rio Conchos at Delicias, Mexico © Edward Parker / WWF Canon





Watershed
Irrigation
Rivers
Reservoirs

RIO SÃO JOÃO
IN BRAZIL

Replanting river-side forest.
© Consorcio Intermunicipal Lagos São João.

Context

Coastal lagoons in the São João region of Brazil had become polluted with untreated sewerage, causing a collapse in the fishing industry and impacting on tourism. It is feared that climate change would exacerbate the impact of pollutants and further diminish the fish and other aquatic wildlife.

Intervention

WWF intervened to promote establishment of multi-stakeholder river basin management institutions to progressively fix the region's environmental problems, facilitating an economic resurgence.

Impacts and benefits

Waste water discharge has been cut by 75%, reducing the prospect of warmer temperatures exacerbating pollution impacts. Wetlands are being restored, increasing the likelihood of species and ecosystems surviving severe climatic events. Soon fish will again be able to migrate past the river's major dam from the mountains to sea, enabling species to move to places where they may shelter from warmer waters.

Lessons

The key lessons from adaptation at São João are institutional. Establishment of effective, local multi-stakeholder institutions that practised subsidiarity has engaged a broad spectrum of the local community and empowered them to take action to restore their environment. This was partly possible due to effective national and state water laws that gave the basin institutions mandates and access to adequate funding sources. The basin institutions have taken an iterative, adaptive management approach to addressing environmental problems, and by achieving substantial early successes, have inspired community confidence and further support for new interventions.

Left: Planned closure of the by-pass canal (top, left) will restore the Rio São João's lower reaches (centre), Brazil © Edward Parker / WWF-Canon.
Right: The São João Consortium has reduced pollution discharges, Brazil
© Edward Parker / WWF-Canon.

Women collecting water, Ruaha basin. © Brent Stirton / Getty images / WWF-UK

About WWF

With a global network covering more than 100 countries and nearly 50 years of conservation work behind us, WWF is one of the most experienced environmental organisations in the world, actively contributing to delivering freshwater projects and programmes around the world.

August 2008

The full report is available online at:
http://www.wwf.org.uk/researcher/issues/freshwater/
http://www.panda.org/about_wwf/what_we_do/freshwater

Acknowledgements

Report compiled for WWF UK, with considerable assistance of the WWF network and many partner organisations, by Jamie Pittock, WWF Research Associate, Fenner School of Environment and Society, Australian National University.

A WWF project supported by the HSBC Climate Partnership

Formed in 2007, the HSBC Climate Partnership brings together HSBC, The Climate Group, Earthwatch Institute, Smithsonian Tropical Research Institute and WWF to tackle the urgent threat of climate change on people, water, forests and cities.

For more information visit **www.hsbc.com/committochange**

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

HSBC Climate Partnership

Designed by www.luminous.co.uk

www.panda.org/freshwater

WWF

for a living planet®

WWF International

Avenue du Mont-Blanc
1196 Gland
Switzerland
t: +41 22 364 9111
f: +41 22 364 8836