THE FORGOTTEN INFRASTRUCTURE: SAFEGUARDING FRESHWATER ECOSYSTEMS

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The water strategies of the 20th century helped to supply drinking water, food, flood control and electricity to a large portion of the human population. These strategies largely focused on engineering projects to store, extract and control water for human benefit. Indeed, it is hard to fathom today's world of 6.6 billion people and more than $65 trillion in annual economic output without the vast network of dams, reservoirs, pumps, canals and other water infrastructure now in place. These projects, however, have often failed to distribute benefits equitably and have resulted in the degradation, or outright destruction, of natural freshwater ecosystems that in their healthy state provide valuable goods and services to society.

As water stress and the risks of climate change deepen and spread around the world, policies and strategies designed to meet human needs, while protecting ecosystem health, will become increasingly critical to human well-being. Scientific understanding of the components of freshwater ecosystem health has advanced markedly over the last decade, but incorporation of this knowledge into water policy and management has lagged. A number of nations and regions—including Australia, the European Union, South Africa and the Great Lakes—are pioneering policies that establish boundaries on human degradation of freshwater with an aim of safeguarding ecosystem health. Although imperfect, and facing tough implementation obstacles, these policies offer promising ways of better harmonizing human uses of water with protection of valuable ecosystems.

The Decline of Ecological Infrastructure

Water infrastructure typically refers to the collection of dams, levees, canals, pipelines, treatment plants and other engineering works that help provide water services to the human population. There is another class of infrastructure that also delivers valuable services to society: the aquatic ecosystems that perform nature's work. Healthy rivers, floodplains, wetlands and forested watersheds supply much

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more than water and fish (see Table 1). When functioning well, this "eco-infrastructure" stores seasonal floodwaters, helping to lessen flood damages. It recharges groundwater supplies, which can ensure that water is available during dry spells. It filters pollutants, purifies drinking water and delivers nutrients to coastal fisheries. Perhaps most importantly, it provides the myriad habitats that support the diversity of plants and animals that perform so much of this work.

For millennia, human societies grew and flourished by relying on this time-tested work of nature. The ancient Egyptians, for instance, thrived for several thousand years on the ecological services provided by the annual flood of the Nile River, which delivered water and nutrients to their farm fields, carried off harmful salts that had accumulated in the soil and supported a diversity of fish.[1] During the 20th century, however, such reliance on nature's services was supplanted by engineering projects that provided hydroelectric power, intensive irrigation, flood control and other benefits demanded by burgeoning populations and economies.

Since most of nature's services lie outside of commercial markets and are not priced in conventional ways, they are grossly undervalued. While the benefits of dams and other water projects are measured in familiar metrics—kilowatt-hours generated and hectares irrigated and populations served—the ecological downsides of these engineering approaches have largely been left out of the cost-benefit calculus. As a result, ecological infrastructure has been dismantled and degraded at a rapid rate. An estimated 25 to 55 percent of the world's wetlands have been drained, 35 percent of global river flows are now intercepted by large dams and reservoirs and more than 100 billion tons of nutrient-rich sediment that would otherwise have replenished deltas and coastal zones sits trapped in reservoirs.[2] River flows are turned on and off like plumbing works, eliminating the natural flow patterns and habitats upon which myriad life forms depend.[3]

It is difficult to place a dollar value on any one piece of eco-infrastructure, but in 2005, scientists participating in the Millennium Ecosystem Assessment estimated that wetlands alone provide services worth $200 to 940 billion per year.[4] Following the Great Midwest Flood of 1993, U.S. researchers estimated that restoration of 5.3 million hectares of wetlands in the upper portion of the Mississippi-Missouri watershed, at a cost of $2 to 3 billion, would have absorbed enough floodwater to have substantially reduced the $16 billion in flood damages that resulted from that one major flood episode.[5] And when Hurricane Katrina struck the U.S. Gulf Coast in August 2005, an important piece of nature's protective infrastructure was partially missing: coastal wetlands and barrier islands that could reduce the power of storm surges. The state of Louisiana alone has lost 492,000 hectares of coastal wetlands since the 1930s, and continues to lose them at a rate of more than 6,200 hectares per year—approximately one football field every forty-five minutes.[6] It is impossible to know

Table 1: Life-Support Services Provided by Rivers, Wetlands, Floodplains and Other Freshwater Ecosystems

- Provision of water supplies for irrigation, industries, cities, and homes
- Provision of fish, waterfowl, mussels, and other foods for people and wildlife
- Water purification and filtration of pollutants
- Flood mitigation
- Drought mitigation
- Groundwater recharge
- Water storage
- Provision of wildlife habitat and nursery grounds
- Soil fertility maintenance
- Delivery of nutrients to deltas and estuaries
- Delivery of freshwater flows to maintain estuarine salinity balances
- Provision of aesthetic, cultural, and spiritual values
- Provision of recreational opportunities
- Conservation of biodiversity, which preserves resilience and options for the future

Source: Sandra Postel, *Liquid Assets: The Critical Need to Safeguard Freshwater Ecosystems* (Washington, D.C.: Worldwatch Institute, 2005).

how many lives and homes might have been saved had natural protections along the coast remained in place. But surely one of Katrina's lessons is to enlist nature's help in mitigating future disasters rather than simply assigning it blame when disasters occur.

Indeed with climate change impacts unfolding more rapidly than scientists had predicted even five years ago, the value of protecting and restoring ecological infrastructure is rising. Global warming and its anticipated effects on the hydrological cycle will make the robustness and resilience of nature's way of mitigating disasters all the more important, as tropical storms, spring flooding and seasonal droughts increase in frequency and/or intensity.

South Africa and Australia Pioneer Environmental Flow Policies

To suggest that the maintenance and repair of ecological infrastructure should be a core principle of water policy and planning might sound about as necessary as suggesting a building's foundation be secure before constructing twenty stories on top of it. In reality, however, the systems of water law and policy that guide water allocation rarely give ecosystems the water they need in order to carry out their functions. However, at least two nations—South Africa and Australia—are advancing a new policy framework that places ecological health and the water required to sustain it squarely at the center of water allocation and management.

Simply framed, the old water mindset held that water acquires value only when it is extracted from the natural environment and put to use by a farm, factory or home. The evolving new mindset recognizes water's value when left in place to do its ecological work. Perhaps no nation is working harder than South Africa to shift from the old way of thinking about water to the new, more environmentally intelligent view. After coming to power in 1994, Nelson Mandela's post-apartheid government undertook a rewriting of the country's constitution and laws, and water reform was near the top of the agenda. "There was a desire to reshape water management so as to transform South African society," according to Evan Dollar, a river scientist with South Africa's Council for Scientific and Industrial Research. "We were given a unique historical opportunity to do so."[7]

South Africa's National Water Act of 1998 was the result of that process.[8] The law was grounded firmly in the doctrine of public trust—the recognition that governments hold certain rights and entitlements in trust for the people and are obligated to protect them for the common good. One of the innovative features of the law is the establishment of a water reserve consisting of two parts. The first is a non-negotiable water allocation to meet the basic drinking, cooking and sanitary needs of all South Africans.[9] The second part of the reserve is an allocation of water to support ecosystem functions so as to secure the valuable services they provide to South Africans. Specifically, the act says:

> The quantity, quality and reliability of water required to maintain the ecological functions on which humans depend shall be reserved so that the human use of water does not individually or cumulatively compromise the long-term sustainability of aquatic and associated ecosystems.[10]

The water determined to constitute this two-part reserve has priority over irrigation and other licensed uses, and only reserve water is guaranteed as a right. What the South African law says, in effect, is that both people and ecosystems must get the water they need to be healthy before other water demands are fulfilled. Not surprisingly, the pioneering law is far easier to express on paper than to implement on the ground. Because the human reserve amounts to little more than 25 liters per person per day (certainly better than no access to safe drinking water at all, but a sparse daily allotment), many poor black South Africans view the law as a perpetuation of historical inequities.

The ecological reserve has solid scientific underpinnings but is difficult to implement. Just as doctors check blood pressure, cholesterol levels and heart rate to see if these values fall within ranges essential for good human health, scientists assess certain ecosystem attributes to determine whether they fall within ranges essential for good ecological health. With sufficient information about a particular river system, scientists can develop an "environmental flow prescription"—a description of the quantity and timing of flows required to sustain an ecosystem's important functions. The approach calls for water managers to sustain or replicate a river's natural pattern of variable flows—the pattern of high and low flows, as well as periodic floods and droughts—that the river historically exhibited and to which the myriad life forms in the river have become adapted.[11] The approach does not call for or require a return to the "natural" state, but it does entail maintaining a flow regime that resembles the natural historical one to a sufficient degree to sustain the ecological functions of the aquatic system.

South African scientists have done pioneering work in the development of environmental flow methodologies, and these are informing both the policy and its implementation. However, tying flows to the provision of specific ecosystem goods and services—for example, maintaining populations of floodplain fisheries that local people rely on for protein—is complicated. Nonetheless, South Africa's scientists and citizens are tackling these issues. According to Dollar, more than 300 reserves, about 30 percent of the total needed, have been established and await implementation by water managers.[12]

Australia also began a major move toward more ecologically minded water management in 1994, when state premiers signed on to a new Council of Australian Governments (COAG) Water Reform Framework Agreement that aims to "sustain and where necessary restore ecological processes, habitats and biodiversity in water dependent ecosystems."[13] A key piece of this reform package calls for states to recognize the environment as a legitimate user of water and to allocate water specifically to freshwater ecosystems. Among the twenty guiding implementation principles—which cover issues ranging from assessing ecological flow requirements to accountability and community involvement—is one stating explicitly that environmental water provisions should be legally recognized. Another says that when environmental water allocations are not sufficient to prevent significant ecological harm, extractions of water from that river basin "should be capped."

All eight Australian states have passed new water laws to reflect the COAG goals and they are now in the process of setting environmental flow requirements for their rivers. Under the nation's constitution, the commonwealth (or federal) government has limited authority over water matters; primary responsibility rests with the states and territories. Implementation of these water reforms may, thus, vary considerably among the states. The state of Western Australia, for example, has established a water allocation policy similar to South Africa's ecological reserve: the water required to support ecosystem health gets top priority; the remainder can then be licensed for other uses.[14] Since Western Australia's rivers generally are not yet over-allocated, the setting of these environmental flows early on may avoid the contentious issues that inevitably arise in river basins that are already stressed or over-allocated.[15]

Indeed, in the grip of a multi-year drought, many Australian river basins are running squarely into a major hurdle when it comes to implementing environmental flow strategies—consumptive water-use entitlements that are expressed as specific quantities rather than as shares of the pool of water actually available. In heavily allocated river systems, the only way to ensure that ecosystems receive their sustaining flows is if private water rights or permits within the river system are reduced during droughts to an equitable proportion of the water actually available in the system once the ecological requirements are met. Even clearly defined environmental flow allocations will not be respected if property rights in water are not adjusted during periods of drought-induced water shortages—a situation likely to become much more frequent in some regions as climate change unfolds.[16]

Many of these issues are coming to a head in the Murray-Darling River Basin, Australia's largest watershed and home to 70 percent of the nation's irrigated land.[17] After a tripling of withdrawals between 1944 and 1994, river flows dropped to ecologically harmful levels. Wetlands shrank and fish populations declined, while salinity levels and the frequency of algal blooms increased. Severe low-flows now occur in the lower Murray River in nearly two years out of three (and every year during the ongoing drought), compared with 5 percent under natural conditions. The Murray's flow has dropped so low during recent drought years that its mouth has became clogged with sand.[18]

The Murray-Darling watershed spans parts of four states and all of the Australian Capital Territory. Through the Murray-Darling Basin Commission (MDBC), these political entities work cooperatively to manage the river. In 1997, in response to the rapid deterioration of the river's health, the Ministerial Council (which consists of resource ministers from each basin state or territory plus the commonwealth) placed a cap on diversions from the basin. According to the MDBC, 96 percent of the water consumed within the basin in 2003-2004 was within the cap.[19]

With a lid on extractions, new water demands in the Murray-Darling basin are met primarily through conservation, efficiency improvements and water trading. Most of the early buying and selling of water entitlements has occurred within states, but the MDBC is now piloting a program in the southern portion of the basin to allow permanent water trades across state boundaries.[20] The initial two-year review of this scheme found that it had enabled fifty-one trades collectively worth about 10 million Australian dollars, which had transferred nearly 10 million cubic meters of water between states.[21] With virtually all of the traded water going to higher-value uses, water marketing is boosting the basin's money economy. Indeed, a 1999 study projected a doubling of the basin's economic value over twenty-five years with the cap and water reforms in place.[22]

The ecological benefits of the cap, however, are far from certain. The cap was pegged to a level of withdrawals that had allowed serious degradation of the river's health. So while it may prevent further deterioration, the cap is not sufficiently stringent to revitalize the river. Moreover, the prolonged drought has exacerbated the decline in the river's health.

In early 2007, the commonwealth government responded to the dire situation of the Murray-Darling Basin—the drought in general—by passing a National Plan for Water Security under which the government will invest up to $3 billion over ten years to address the over-allocation of water in the basin. The intention appears to be to buy back between 15 and 30 percent of water entitlements in the southern part of the basin in order to return flows to the river. By any accounting, this is a big move. The volume of water that could be purchased (at current market prices) through the planned buyback of entitlements is at least fifteen times greater than the total amount of permanent water entitlements that have ever been traded in a given year.[23] The MDBC has announced that it is prepared to buy water from willing sellers and has set up a mechanism for entitlement holders to express their interest in doing so. However, it is still unclear whether the large volumes of water sought for the Murray River environment will be forthcoming voluntarily or whether mandatory measures will be needed.

Environmental Flows and a Cap in the U.S. State of Texas

In the United States, two centuries of dam building, levee construction and straightening of river channels have left very few river segments in anything close to their natural state: Only 2 percent of U.S. rivers and streams remain free-flowing.[24] Conflicts over the allocation of water between human needs and ecosystem needs have been intensifying across the country, from west to east and north to south. Nevertheless, despite widespread degradation of its river systems, the United States has no overarching vision or goal to secure river flows that support the diversity of freshwater life and that sustain ecological functions. Historically, the federal government has deferred to the states in matters of water allocation, use and management. Consequently, water policy innovations have tended to emerge from state and regional authorities rather than from above.

One perhaps unlikely policy pioneer in the establishment of environmental flows is the state of Texas. In 2007, Texas passed one of the most comprehensive statewide environmental flow laws in the country, the Environmental Flows Allocation Process. It calls for the setting of flow standards for every major river system in the state and establishes a process for soliciting input from both scientists and stakeholders in each watershed. Texas boasts a $2 billion a year recreational and commercial fishing economy along its coast, and this valuable asset depends on adequate freshwater flows into its bays and estuaries.[25] The Texas coastline also offers premier bird habitat and supports a world-renowned diversity of bird species. Among these species is the endangered whooping crane, which spends winters near the mouth of the Guadalupe and San Antonio rivers. Bird enthusiasts flocking to the Texas coast provide another source of tourist dollars that depend on healthy rivers.

Like the Murray River in Australia, the Rio Grande in Texas runs dry before reaching the Gulf of Mexico in times of drought, and with the state's population growing rapidly, more rivers and estuaries are at risk of water deprivation. The new legislation emerged from negotiations between environmental groups and water suppliers and stands a good chance of passage. The law calls for each river basin in the state to be guided by a team of scientists (the Environmental Flows Science Committee) and a team of stakeholders (the Environmental Flows Advisory Group) representing diverse interests, and for the state environmental commission to consider the recommendations of both groups in setting formal environmental flow standards. In doing so, the commission may decide to set aside some or all of the water not yet permitted for other uses to secure future environmental flows. Where rivers are already over-allocated, the commission will examine recommendations from the stakeholder groups as to how to make up the difference, which could include, for instance, dedicating municipal wastewater return flows to environmental flow purposes or soliciting donations and voluntary sales of existing water rights.

A main goal of the flow standards is to ensure sufficient freshwater flows to protect associated estuarine ecosystems, including during times of drought. In November 2007, the flow-setting process was to begin with the Sabine Lake and the Galveston Bay estuaries and their contributing river basins.[26] As in South Africa, the implementation of this Texas law may prove challenging in light of the need to solicit and coordinate stakeholder and scientific involvement. This participation is critical, however, to widespread support and long-term success.

Another water policy initiative in Texas mirrors the cap-and-trade approach being tried in Australia's Murray-Darling Basin. However, in the Texas case, the cap applies to groundwater pumping from an underground aquifer rather than river withdrawals. The Edwards Aquifer is a major source of irrigation water in south-central Texas and of drinking water for the city of San Antonio.[27] By the early 1990s, heavy pumping from the aquifer had substantially reduced flows in San Marcos and Comal Springs, which harbor seven species listed under the U.S. Endangered Species Act—including the Texas Blind Salamander and the Fountain Darter. The Sierra Club and others filed a lawsuit under the act to limit pumping so as to sustain flows in the springs. In response, the Texas legislature established the Edwards Aquifer Authority in 1993 and set a 555.3 million cubic meter cap on annual pumping from the aquifer through 2007 and a more stringent cap of 493.6 million cubic meters by 2008.[28] In addition, the authority is to have enforceable procedures in place by 2012 to ensure continuous minimum flows for the two springs.

As in the Murray-Darling Basin, the cap on withdrawals from the Edwards Aquifer has fostered an active water market. Most of the trades, which include both permanent sales and temporary leases of water, involve irrigators selling water to San Antonio. As of 2005, irrigators had traded some 185.1 million cubic meters of water per year to urban users.[29] The cap has also encouraged more conservation in San Antonio, where per capita domestic use is now considerably lower than in most Texas cities.[30]

The institution of the Edwards Aquifer cap represents a marked departure from Texas's long-standing "rule of capture"—sometimes called the "rule of the biggest pump"—which essentially allows landowners to withdraw as much groundwater from beneath their land as they want, as long as they put it to some beneficial use. Harm to neighbors or the environment does not constrain pumping rights under the rule of capture. This antiquated rule still governs much of the groundwater in Texas, but perhaps experience with the Edwards Aquifer will encourage broader policy reform.

International Initiatives: the Great Lakes and the European Union

The setting of criteria for ecological health within international watersheds is fraught with complexity. Within the last eight years, however, two important initiatives have emerged that offer the potential for large-scale protection of rivers, lakes and aquifers in a portion of North America and much of Europe. One is the Great Lakes Charter Annex and related agreements. The other is the European Union's Water Framework Directive.

The Great Lakes–St. Lawrence River Basin is a vast watershed that spans portions of eight U.S. states (Illinois, Indiana, Michigan, Minnesota, New York, Ohio, Pennsylvania and Wisconsin) and two Canadian provinces (Ontario and Quebec). About 95 percent of North America's surface freshwater supply is contained within this basin. Since 1985, the ten Great Lakes Basin (GLB) states and provinces have abided by principles set forth in the Great Lakes Charter, a bilateral agreement intended to protect the Great Lakes ecosystems. However, with increased talk about the possibility of bulk exports of water from the Great Lakes to drier parts of North America and the world, the GLB states and provinces entered into a supplementary agreement in 2001, the Great Lakes Charter Annex, which commits the ten parties to develop stronger protections for the waters and ecosystems of the Great Lakes.

Several years of public and official discussions followed, and on 13 December 2005, the eight Great Lakes governors and two premiers signed agreements to reform the rules for taking water from the aquifers, rivers or lakes in their respective states and provinces within the GLB. The first is a good-faith agreement among all ten parties; the other is a binding compact among the eight U.S. states.[31] The big gorilla of these agreements is a ban on most water diversions from the Great Lakes ecosystems, with an eye toward meeting a no-net-degradation goal for the Great Lakes ecosystem. Exceptions to the export ban are made for relatively small water withdrawals and for communities that straddle the watershed's boundaries. However, even small- and mid-size withdrawals are subject to review based on environmental criteria and sustainable water use provisions. The compact says, for example, that even withdrawals meeting the criteria for exception from the ban can be allowed only if the water withdrawn is returned to the source watershed (less some allowance for consumptive use of the water). Moreover, it largely precludes parties from satisfying this return requirement with waters from outside the basin to protect against the introduction of invasive species.[32]

Implementation of these provisions hinges on all the U.S. states ratifying the compact and passing virtually identical legislation to implement it—certainly a nontrivial hurdle. Although the compact was signed more than two years ago, so far only two states have ratified it—Minnesota (February 2007) and Illinois (August 2007). Ratification is pending in the other states. Once all the states have ratified it and passed implementing legislation, the U.S. Congress would need to approve the compact for it to become enforceable federal law. In Canada, the ban on diversions is much less controversial than it is in the United States, and so full implementation by Ontario and Quebec is expected. Ontario already meets or exceeds most of the requirements of the Charter Annex agreements. The province has already passed strict laws banning diversions out of the province's three major water basins, which include the Great Lakes–St. Lawrence River Basin.[33]

Even as progress continues on the legislative front, actions are being taken to ensure effective implementation of the agreements. For example, on 4 December 2007, the regional body overseeing implementation of the agreements adopted regional water conservation and efficiency goals and objectives. The water conservation initiative will now assist the ten Great Lakes states and provinces in working together to develop more specific conservation goals, and will serve as an ongoing forum for the involvement of tribes, first nations, regional stakeholders and others.[34] It is important to note that application of the "precautionary principle" underpinned the development of this protective water policy for the Great Lakes. As applied to ecological health, the precautionary principle essentially says that given the rapid pace of ecosystem decline, the irreversible nature of many of the resulting losses and the high value of freshwater ecosystem services to human societies, it is wise to err on the side of protecting too much rather than too little of the freshwater habitat that remains. It operates like an insurance policy—society buys extra protection in the face of uncertainty. In what is perhaps the strongest recognition of the precautionary principle by an international water institution, the International Joint Commission adopted this as a guiding principle for protecting the Great Lakes. In a 1999 report to both governments, the commission cites the precautionary approach as one of five principles, noting:

> Because there is uncertainty about the availability of Great Lakes water in the future—[a]nd uncertainty about the extent to which removals and consumptive use harm, perhaps irreparably, the integrity of the Basin ecosystem—caution should be used in managing water to protect the resource for the future. There should be a bias in favor of retaining water in the system and using it more efficiently and effectively.[35]

With passage of its Water Framework Directive (WFD) in 2000, the European Union has also taken an important step toward the protection of freshwater ecosystems. Up until that time, the EU had primarily focused on water quality concerns, but with the new WFD a more comprehensive approach to freshwater ecosystem health is squarely on the agenda. A key feature of the directive is the establishment of criteria for classifying the ecological status of rivers (and other water bodies) as high, good, moderate, poor or bad, depending upon how much the water body's ecological characteristics deviate from a natural or undisturbed condition.[36] Member countries are then to take measures to ensure that at least a "good status of surface water and groundwater is achieved...and that deterioration in the status of waters is prevented."[37] Each member country has responsibility for translating the directive into legislation and for adopting implementation measures, which are likely to include controls on water withdrawals and flow alterations. Importantly, the directive establishes criteria for classifying the ecological status of rivers, including river flow and channel characteristics.

Of the 110 river basins identified within EU member states, forty cross national borders. With these forty international basins constituting 60 percent of the EU's territory, cooperation among countries is critical for successful implementation of the WFD.[38] Considerable progress in international coordination has already been achieved in the Elbe, Meuse, Odra, Rhine and Scheldt basins—and especially within the Danube basin, where initiatives were well under way long before the directive's passage. Rising in Germany's Black Forest, the Danube joins thirteen countries and over 80 million people within its watershed as it runs approximately 2,800 kilometers eastward to the Black Sea. Over the past two centuries, the river has been badly degraded by channelization, draining of wetlands, rampant pollution and the construction of numerous dams—including fifty-nine along the river's first 1,000 kilometers. A good portion of the Danube's riparian forests are gone and former floodplains have dried out. In Bulgaria, for instance, 90 percent of the river's floodplain wetlands have disappeared.[39] Moreover, the Danube Delta—Europe's largest wetland ecosystem and home to 320 species of birds—has been seriously degraded by the heavy pollution loads carried downstream and by the reduction of cleansing flood flows.[40]

After the breakup of the Soviet bloc and the fall of the Iron Curtain, new opportunities for cooperation and collaboration arose for the nations of the Danube watershed. They did not waste much time. In September 1991, the environment ministers from a number of Danube countries met in Sofia, Bulgaria to begin planning the river's restoration and protection. In June 1994, a majority of Danube countries, plus the European Commission (the decisionmaking arm of the EU) signed the Convention on Cooperation for the Protection and Sustainable Use of the Danube River, a legal instrument that directly calls for sustainable and equitable water management.[41] Later that year, in Bucharest, Romania, the environment ministers and the EU's environmental commissioner endorsed the Danube Strategic Action Plan, which states that "[c]onservation, restoration and management of riverine habitat and biodiversity is important for maintaining the natural capital of the basin...and to establish its natural purification and assimilative capacity."[42]

Remarkably, the Danube collaboration brings together former communist countries with their Western counterparts, and relatively rich nations such as Germany and Austria with poor ones such as Bulgaria and Romania. A key benefit of a cooperative river-basin framework is that it allows international agencies and groups to fund and help implement projects. For instance, the governments of Bulgaria, Romania, Moldova and Ukraine have pledged to create a network of at least 600,000 hectares of floodplain habitat along the lower Danube, the Prut River and in the Danube Delta.[43] This joint effort is part of a project called Green Corridor for the Danube, initiated in June 2000 by the World Wildlife Fund, a private conservation organization. With funding from United Nations agencies and others, the project aims initially to demonstrate how healthy floodplains can provide habitat, reduce pollution loads and enhance fisheries. The hope is to extend the Green Corridor program to the entire length of the Danube.[44]

For Romania, which harbors more than 80 percent of the Danube Delta, restoration of the ecosystem must be accompanied by a reinvigoration of its weak economy. There—as in South Africa and most poor countries—citizens are only likely to support ecosystem restoration efforts if their livelihoods improve at the same time. Whether an upstream-downstream collaboration can meet this difficult test of sustainable development remains to be seen. One key to success will likely be acknowledging the value of revitalized ecosystem services. According to one estimate, a $275 million investment in wetland restoration in Romania alone would be recouped within six years from the ecosystem goods and services provided by the delta—including reduced pollution loads, flood control and regenerated fisheries.[45]

In addition to encouraging greater international cooperation for ecosystem restoration, the WFD is giving new impetus to more ecologically sound flood management. A new directive on the Assessment and Management of Flood Risks came into force in November 2007 and calls for the preparation of flood hazard maps and flood risk management plans that are aligned with the WFD's environmental objectives.[46]

The flood directive comes on the heels of several years of severe and costly flood damages. Between 1998 and 2002, European countries experienced a hundred major floods—including extreme events along the Danube and Elbe rivers—that collectively caused 700 deaths, the displacement of half a million people and economic losses totaling 25 billion euros.[47] More than 10 million people live in areas at risk of extreme floods along the Rhine River, a heavily channelized waterway that no longer meanders but flows artificially straight between engineered embankments.[48] In its upper reaches, the river is cut off from 90 percent of its original floodplain.[49] The Rhine now flows twice as fast as it did before, and flooding in the basin has grown more frequent and damaging. The European Commission estimates that assets worth 165 billion euros are potentially at risk from flooding of the Rhine.[50]

It is too early to judge the effectiveness of the EU's WFD. Nonetheless, most member states have made significant progress since the directive came into force. The Common Implementation Strategy has created a network of one hundred experts from over thirty countries and twenty-five pan-European stakeholder and other organizations that are providing input into the process and providing a platform for building implementation capacity. Among the shortcomings to date is the inadequate transposition of the WFD into national law. The identification of water bodies at risk of failing to achieve the WFD objectives is a critical part of the knowledge base required to develop effective river basin management plans. In general, however, there is insufficient data for member states to evaluate these risks for a large share of water bodies and in some cases, insufficient evidence that states are even committed to gathering the needed data.[51]

On paper, however, the EU's WFD offers great promise for protecting and restoring ecological flows for Europe's rivers. It has already provided new standards against which organizations and agencies can judge proposed water projects and plans. For example, opponents of the large-scale river diversions that have been part of Spain's national hydrological plan have pointed out that the plan—for which Spain had sought European Community funding—is at odds with the principles and objectives established by the new European water policy directive.[52]

Moving Forward

Rivers, floodplains, wetlands and watersheds constitute ecological infrastructure of increasing value that warrants protection. Policies that safeguard ecological services aim to maximize the full value of water to society, taking into account both extractive uses of water as well as water's functions within the natural environment. By setting boundaries on the degree to which human activities degrade ecosystems and their services, these policies can help maintain this ecological infrastructure into the future. Moreover, establishing these boundaries will unleash the potential of water conservation and efficiency measures to meet new water demands without extracting more water from natural ecosystems. As such, it will drive up water productivity—the value society derives from each liter of water extracted—while keeping ecological infrastructure intact.

With the impacts of climate change unfolding faster than scientists had predicted even five years ago, adopting policies that preserve the robustness and resilience of nature's way of mitigating floods, droughts and other disasters will be especially critical. Maintaining and expanding ecological infrastructure—including healthy rivers, wetlands and floodplains—is a key element of effective climate adaptation strategies.

Over the last decade, a number of national, regional and international governing bodies have adopted water policies specifically aimed at protecting freshwater ecosystems and their services. The implementation of these policies—within South Africa, Australia, the Great Lakes basin, U.S. states such as Texas and the European Union—warrant support and attention.

NOTES

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[8] *South African National Water Act* No. 36 1998 (note 11), Part 3: "The Reserve;" and Appendix 1: "Fundamental Principles and Objectives for a New Water Law in South Africa."

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