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Clear Necessity

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ENTREPRENEURIAL SOLUTIONS TO GLOBAL CHALLENGES

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Organization of the Journal

Each issue of *Innovations* consists of four sections:

1. Lead essay. An authoritative figure addresses an issue relating to innovation, emphasizing interactions between technology and governance in a global context.

2. Cases authored by innovators. Case narratives of innovations are authored either by, or in collaboration with, the innovators themselves. Each includes discussion of motivations, challenges, strategies, outcomes, and unintended consequences. Following each case narrative, we present commentary by an academic discussant. The discussant highlights the aspects of the innovation that are analytically most interesting, have the most significant implications for policy, and/or best illustrate reciprocal relationships between technology and governance.

3. Analysis. Accessible, policy-relevant research articles emphasize links between practice and policy—alternately, micro and macro scales of analysis. The development of meaningful indicators of the impact of innovations is an area of editorial emphasis.

4. Perspectives on policy. Analyses of innovations by large scale public actors—national governments and transnational organizations—address both success and failure of policy, informed by both empirical evidence and the experience of policy innovators. The development of improved modes of governance to facilitate and support innovations is an area of editorial focus.

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Brian Richter

Sustainable Water Use: Can Certification Show the Way?

Water is the core of our being. Two-thirds of the human body is made up of water, and we must continually replenish it. Analogous to losing oil in an automobile, being down only a few quarts of water can be fatal to humans. But it takes a lot more than drinking water to keep us healthy. We need water for cooking and bathing. We need water to grow food and generate electricity, to produce the clothes on our backs and the countless other goods we use in our daily lives.

The challenges associated with meeting the water needs of a global population racing toward the seven billion mark are expansive and daunting. Today, more than one billion people lack access to safe, clean drinking water, nearly one billion are malnourished, two billion are without electricity, and more than five hundred million are harmed by floods every year.

Fortunately, many governments and organizations around the world are working to alleviate these social maladies. In September 2000, the General Assembly of the United Nations, cognizant of the growing global dimensions of poverty and inspired by the dawn of a new millennium, came forth with a bold and far-reaching pledge that was signed by 189 nations. The Millennium Declaration, a commitment to reduce extreme poverty, set a series of goals with a 2015 deadline that have become known as the Millennium Development Goals. The breathtaking scope of these goals includes addressing poverty and hunger, universal education, gender equality, child health, maternal health, HIV/AIDS, environmental sustainability, and global partnerships. Among these laudable efforts are specific commitments to cut in half the number of people who suffer from hunger or are unable to access or afford safe drinking water.

Brian Richter has been involved in river science and conservation for more than 20 years. He is the Managing Director of The Nature Conservancy's Global Freshwater Program, an initiative that is supporting conservation projects across the Americas, Asia, Africa, and the Pacific Region. Brian has developed numerous scientific tools and methods to support river protection and restoration efforts, including the Indicators of Hydrologic Alteration software that is being used by water managers and ecologists worldwide. He is co-author (with Sandra Postel) of "Rivers for Life: Managing Water for People and Nature" (Island Press, 2003). Brian has provided scientific or technical consultation on more than 120 river projects worldwide.

The Millennium Declaration is equally explicit about the need to pursue the alleviation of poverty in an environmentally sustainable manner: “We must spare no effort to free all of humanity, and above all our children and grandchildren, from the threat of living on a planet irredeemably spoilt by human activities, and whose resources would no longer be sufficient for their needs.”[1]

The Millennium Development Goals, however, also carry an embedded conundrum, because attaining these goals will put considerable additional strain on the planet’s water resources. Most of the hydrologic systems presently being tapped for human purposes already have been driven into a biologically degraded and unsustainable condition. Even in the U.S., where water regulations are quite strong, more than 40 percent of rivers and streams and more than 60 percent of lakes are “impaired.”[2] And yet, the Millennium Declaration holds us to high standards of environmental sustainability. The bottom line: in order to achieve the Millennium Development Goals, we will have to use the world’s water supplies even more heavily while at the same time substantially restoring many freshwater ecosystems. That’s quite a tall order.

No rulebook on sustainability exists to guide us out of the Millennium Declaration’s water conundrum in a scientifically sound, ethical, and long-lasting manner.

Even the most optimistic water professional would admit that the odds are stacked against us. We lack reliable information about how much water is available and how it is presently being used, uncertainties that will be compounded by climate change. Furthermore, the human population shows little sign of stabilizing outside of Europe, and in some regions of the world, such as Asia, rapid population growth combined with a rising quality of life and increasing consumerism is driving up water demands exponentially. As global traders pounce on the new markets created by this growth, their supply chains are reaching into new watersheds and water sources, which could have an impact on far-distant communities and economies. The water world is highly dynamic, and it will be nearly impossible to win the Millennium Development game when the score is changing so fast on different parts of the game board. Some of the primary hurdles on the road to sustainability—a general lack of information and planning, the influences of global trade, and inequitable distribution of water benefits—are further detailed below.

Perhaps most troubling is the fact that no rulebook on sustainability exists to guide us out of the Millennium Declaration’s water conundrum in a scientifically sound, ethical, and long-lasting manner. One of the Declaration’s specific targets for environmental sustainability is to “integrate the principles of sustainable development into country policies and programmes,” but no such principles exist in the water world, at least none that are broadly endorsed or commonly recited. Terms such as "environmental sustainability" and "sustainable development" ring hollow in absence of realistic, pragmatic, broadly endorsed principles and guidelines for good, smart behavior in managing water. Within this vacuum of lacking guidelines and accurate information, everything from dams to toilets is being marketed as a sustainable water practice.

There are good reasons to create a sustainability rulebook now so that sustainability can become more than just a slogan. This rulebook should encourage water users and managers to take a long-term, macro-level view of the hydrologic systems they use and regulate, and to work to ensure that the physical, biological, and chemical characteristics of those systems are not degraded over time. Practicing true sustainability means finding ways to manage all the well-pumpers who are tapping the same aquifer so that groundwater levels do not decline over time. It means managing the farms in a watershed so that the water and chemicals that wash off those farms do not pollute the river for downstream users. It means anticipating the possibility that climate change could produce a drought unlike any seen before.

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The practice of sustainability is critically important to the world's poor. Sustainability in practice can prevent a subsistence farmer's groundwater well in China from going dry, thereby keeping families and communities fed. It can ensure that the fish feeding a village in Africa won't disappear because the river was polluted by uncontrolled land use or industries upstream. It can guarantee that millions of poor won't go without heat and light in a Brazilian city because a drought shut down the hydropower dams. At the same time, it can allow those of us with the means to travel to distant and remote lands to continue enjoying unspoiled natural beauty. Sustainability can provide insurance that the companies we work for won't be bankrupted when water shortages sever an essential supply chain, and our banks can be assured that the water-related businesses and infrastructure they have invested in will remain solvent. Most important of all, the practice of sustainable water management is responsive to the Millennium Declaration's pledge that our children's children will have the same opportunities in life that we do.

Governments should be the progenitors of sustainable water management, but thus far precious few have demonstrated the will or the ability to make this happen. It will be impossible to attain the water-related Millennium Development Goals by 2015, or even within decades, if we wait for governments to lead the way. The leadership must instead come from those who profit from the use of water—including those who invest in water ventures—even if for no other reason than to protect the goose that lays their golden eggs.

Two emerging certification programs—the Alliance for Water Stewardship and the Hydropower Sustainability Assessment Forum—may help to jumpstart corporate and governmental movement toward water sustainability. Two new alliances were formed to take on the difficult work of building multistakeholder consensus around best practices for sustainability, one focusing on large water users and the other on hydropower dam projects. There is considerable interest in using the sustainability standards emerging from these two efforts as the basis to certify water users who voluntarily practice sustainable water management. The incentives for reaching these standards are not just environmental and social but economic. A brief profile of these two sustainability certification programs is offered later in this paper.

The success of these certification efforts in changing the rules of the water game may very well determine not just the fate of the Millennium Development Goals, but also the way water will move through watersheds, cultures, and economies for generations to come.

DIMENSIONS OF THE WATER CHALLENGE

Since the beginnings of life on Earth, the amount of fresh water on our planet has remained constant. Flowing through rivulets and channels and gathering in lakes and wetlands, this precious resource has given rise to an extraordinary diversity and abundance of life and enabled human civilizations to grow and prosper. But now, at the beginning of the 21st century, with the human population approaching seven billion, communities and businesses around the world are facing the limits of the earth's fresh water.

There would be enough water to support all of humanity, now and for decades to come, if it were evenly distributed around the globe and delivered from the skies at a constant rate. But rain all too often comes as a deluge or not at all, and it is increasingly unpredictable, given the changing climate. The Atacama Desert in northern Chile may go for more than 20 years without rain, whereas Mt. Waialeale on Kauai in the Hawaiian Islands averages more than 40 feet of rain a year.

For most of human history, the vast majority of the global population has lived with the comfort of abundant water. Here in the U.S., the long-running adage was that "water quantity is a problem of the West, but water quality is the problem of the East," implying that the East had water aplenty. But that sense of water security met with a rude awakening in 2002, when rivers and streams throughout much of the Atlantic Seaboard hit their lowest recorded levels. Cities from Atlanta to New York City found their water supplies vulnerable as never before.

A Paucity of Data

From countless newspaper stories and the television news during the 2002 drought, it became clear that residents of eastern U.S. cities were surprised not only by the fact that they were running out of water, but also that their water managers *would let them run out*. This situation created for water managers what parents commonly refer to as "a teaching moment." They pointed out that for many years they had been trying to bring attention to the fact that they lacked access to the basic information needed to manage water well. Accurate data describing how much water is available in each watershed, who is using the water, and how much is being used and when are simply lacking for much of the U.S. And that picture is far worse for the vast majority of the rest of the world.

One water manager equated today's situation with opening a checking account at the bank but not bothering to balance the deposits and debits each month. When you're making good money, you might do fine for awhile, but when the teenagers start recklessly using their debit cards against the account you could be in for a surprise. A teaching moment.

A survey undertaken by the U.S. General Accounting Office in 2003, the year following the drought, found that even under normal conditions, water managers in 36 states anticipated shortages in the next decade. Remarkably, the basic data necessary to make such projections are less available now than they were 40 years ago because there are fewer water-monitoring stations in operation now than in 1968. The U.S. Geological Survey, the primary federal agency collecting water data, has seen its budget slashed repeatedly. The biggest hit came during the Reagan years, from which our federal water data systems have never fully recovered. Sustainable water management will require investing in the data collection necessary to advance our understanding of the hydrologic systems that support us.

Climate Change and Water Shifts

In the February 2008 issue of the journal *Science,* seven international scientists published an article entitled, "Stationarity Is Dead: Whither Water Management?" The term "stationarity" has been used to imply that natural systems fluctuate within an unchanging envelope of variability. Water management systems have long been designed and managed under an assumption of stationarity, which is used to project the likely future from evidence of the past. This is the basis upon which $500 billion of water infrastructure—water-supply reservoirs, flood-control measures, hydroelectric dam turbines—are designed and built each year around the globe. But the punch line from the *Science* article puts the assumption of stationarity on its head: "In view of the magnitude and ubiquity of the hydroclimatic change apparently now under way . . . we assert that stationarity is dead and should no longer serve as a central, default assumption in water-resource risk assessment and planning."

Without a doubt, the brunt of the impact of climate change will fall most heavily on communities lacking reservoirs to store water or plumbing to bring water into homes and businesses. Eighty percent of all water used to grow crops comes directly from the sky rather than from rivers, lakes, or aquifers, and in the developing regions of Africa, Asia, and Latin America, that percentage is considerably higher. Variable rainfall, dry spells, and droughts have always made rain-fed farming a risky business. As climate change begins to shift the timing of that rainfall, the very survival of many poor farmers may rest largely on whether the genes of their crops can hold up despite a lack of stationarity.

Given that water data are already insufficient to support sound water management, climate change threatens to greatly complicate our ability to plan for our water future. In one of the most comprehensive assessments completed to date on the implications for water of climate change, the International Panel on Climate Change concluded that the frequency of heavy rainfall events will *very likely* increase over most areas during the 21st century, with consequences for the risk of rain-related floods. At the same time, the proportion of the land surface in extreme drought at any one time is projected to *likely* increase. Even in those places where rainfall doesn't change much, the increasing evaporation of water from lakes and rivers due to warmer temperatures will mean less water is available for human use.

More subtle changes, such as shifts in the timing of rainfall or snowmelt, can wreak havoc on water-supply systems as well. For instance, more than one-sixth of the world's population is dependent on water from melted mountain snowpack and glaciers. With warming temperatures, less and less water will be stored as snow and ice that melts gradually into rivers in the spring. Instead, winter precipitation will occur increasingly as rain instead of snow, resulting in mountain-fed rivers reaching their highest water levels in the dead of winter rather than during the spring and early summer thaw. Most important, rivers in mountainous regions will begin drying up much earlier, and to a greater degree, in the summer and autumn months. This shift in timing of water runoff will almost certainly cause many water-supply systems to crash, either because storage reservoirs were not physically designed for these new patterns of runoff or because water-supply managers have insufficiently adjusted their plans to capture the water they need. Or both.

The implications of these forecasts for flood and water-supply managers are quite obvious, and disturbing to say the least. Practicing sustainable water management in the brave new climate-changing world will require ever-improving models to forecast future scenarios. But, more important, it will require water managers to hedge their bets about how much water will be available in the future and not to allocate every last drop for human use. As with a personal checking account, if we spend every penny we deposit, we could end up in serious trouble if we have to endure a cut in pay.

The Long Reach of Global Trade

In 1998, the provincial government of Ontario approved a proposal by a private company to export 50 tanker ships full of water each year from the Great Lakes to Asia. The action infuriated citizens of the region, causing the governments of Great Lakes states and provinces to vow to prevent such outrages in the future. Three years later, the governors of the eight states and the premiers of the two Canadian provinces sharing the Great Lakes signed a Great Lakes Annex that substantially constrains out-of-basin diversions of water.

While it is interesting to note the hostile reaction that an overt diversion of water from the Great Lakes engendered, it is a little-known secret that much greater volumes of water are being exported from countries around the world every day. In fact, a volume of water equivalent to 20 Nile rivers is moving from country to country at any given time through global trade.

However, not all of the water being traded is in the tangible form of a tanker ship, nor even as bottled water or other beverages that contain a lot of water. Much of this water trade is "virtual." The term "virtual water" refers to the fact that it takes water to grow food, to produce a cotton shirt, or to make any of the other goods and products that are shipped around the world every day. It takes 37 gallons of water to produce one cup of coffee, 800 gallons to produce a hamburger, and 2,100 gallons to produce a pair of leather shoes because of the water used to grow feed, support a cow, and process its skin into leather to make the shoes. By purchasing these goods from other countries, the buyer country avoids using its own water.

You can readily find estimates on the Internet of the water required to produce all sorts of goods and products, thanks to the pioneering efforts of Dr. Arjen Hoekstra and his colleagues at the University of Twente in the Netherlands. Dr. Hoekstra, his students, and an ever-growing industry of organizations and consultants are now busily calculating the "water footprint" of individual consumer products, of large water-using companies, and even of entire nations.

For example, Ashok Chapagain, a Hoekstra protégé, and his colleague Stuart Orr of the World Wildlife Fund have calculated the water footprint of the United Kingdom at 100 billion cubic meters per year.[3] That's the equivalent of 1,100 Olympic-sized swimming pools full of water being consumed every day. More than 60 percent of that water footprint is created by importing goods from outside of the country, the large majority of which are agricultural products. The single biggest water-using crop imported into the UK is cocoa beans—yes, to make chocolate. Most of that cocoa comes from the African countries of Ghana, Ivory Coast, Nigeria, and Cameroon. But one of the UK's most important "water colonies" is the U.S.—a fact that might come as quite a surprise to Americans who thought they were free of British rule.

This global trade of virtual water has serious implications for efforts to manage water sustainably. Many multinational corporations have supply chains that literally wrap around the globe. To take advantage of growing markets for their

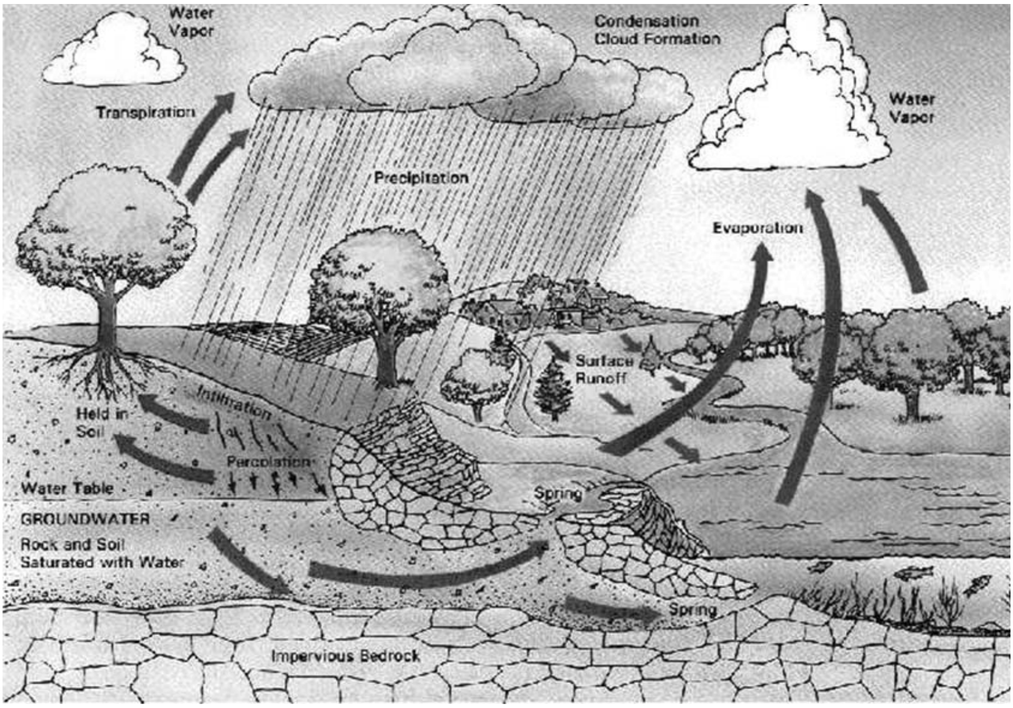


Figure 1. The water cycle.

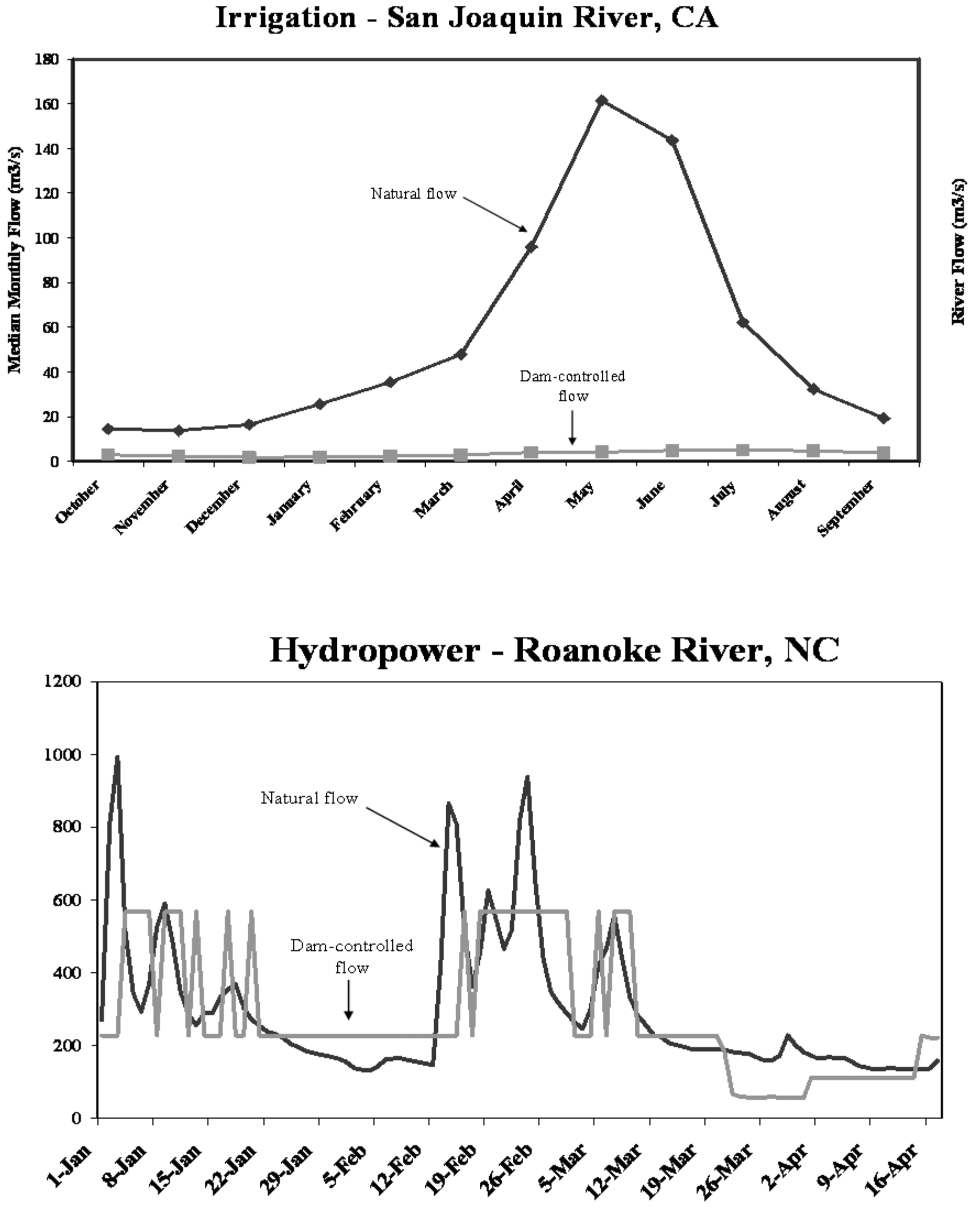
goods in expanding economies such as China or India, these multinationals are constantly researching and tapping into new watersheds from which they can extract water. When a company decides to stop sourcing one of its ingredients from a particular watershed, it might free up water for other uses but it can also destroy local economies if jobs are lost.

No government has yet demonstrated the ability to map or understand the flow of both real and virtual water within its own boundaries, much less among the countries it trades with. No public effort is being made to project the future influence of global trade on a nation's water stock, or on the social values and economies that rely on water assets. And no one has performed a detailed analysis of how climate change might throw this complex water interdependency into disarray. Management of water on a national or global scale, and even on the watershed scale in most regions of the globe, is quite simply a free-for-all.

GREAT POTENTIAL FOR HARM

Humans depend on freshwater ecosystems in many different ways—far too many to be examined within the scope of this paper. The potential for people, especially the poor, to be harmed by the present lack of information and of coordinated and integrated water-resources management is real and it is urgent.

To illustrate the potential for harm caused by unsustainable water use, we can examine a few of the ways that human use changes the flow of water through a



Figures 2a and 2b. River flow in the San Joaquin River (CA) and the Roanoke River (NC).

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river, the impact of this changed flow on ecosystem health, and the consequences for people that depend on the river ecosystem for their well-being and livelihoods. In other words, let's look at this one simple chain that links unsustainable water use to its impact on the poor:

Change in river's water flow patterns →
Damage to river ecosystem →
Harm to people

Human Influences on River Flow

Human activities within a watershed modify the local hydrologic cycle (see Figure 1) in myriad ways. For instance, removing trees from a landscape dedicated to timber harvest or agricultural development can substantially change the amount of water stored in the soil, as well as the amount of water moving through the soil and shallow aquifers into rivers and lakes. However, the effects of landscape changes on local hydrologic systems, even changes as extreme as urbanization, pale in comparison to the impact of directly withdrawing water from rivers, lakes, and aquifers. The over-extraction of water for use by farms and cities has caused even large rivers, such as the Yellow River of China, the Ganges of India and Bangladesh, and the Rio Grande and Colorado in the U.S., to repeatedly go completely dry.

Yet no human influence on our planet's water systems compares with the building of dams. Dams are used to store water for varying lengths of time so that the stored water can be used to control floods, supply water to farms and cities, or generate electricity by releasing it through hydropower turbines. In many cases, the resultant effect on river flow is depletion, as illustrated for California's San Joaquin River in Figure 2a. The dams on the San Joaquin are managed primarily to store water for use in irrigated agriculture. In other cases, little water may actually be removed from the rivers—as in hydropower production or flood control—but operating dams for these purposes can substantially change the natural patterns of river flow, as illustrated for the Roanoke River in North Carolina by Figure 2b (both figures on previous page).

Impact on Freshwater Ecosystems

The plants and animals living in a river ecosystem depend on habitat conditions that are determined largely by the river's level of water flow. That flow can vary considerably over the seasons and from year to year, forming an ever-changing, dynamic mosaic of river habitat. Over centuries and millennia, river species have adapted to the changing habitats created by naturally fluctuating water levels. When salmon are ready to leave the ocean and begin their upriver spawning migration, for example, they wait for the river to rise in flood, thus ensuring that they will have enough water to ascend rocky shoals or small waterfalls to reach their spawning grounds. After the flood season passes, lower water levels and slower currents give recently hatched salmon fry a chance to grow strong enough to maneuver in the river without being washed downstream. When large floods do return, the fish are swept downriver to begin the ocean phase of their life cycle.

Each river-dependent animal or plant has different habitat needs or preferences, which typically vary during their life cycles, as well as different tolerance for unfavorable conditions. A river's native species have been "tested" by nature's variability over thousands of years. If individuals are able to grow and reproduce adequately when conditions are favorable and their population does not lose too many members during hard times, the species is able to persist.

In just the last decade, scientists have learned a great deal about the critical links between variations in natural flow and the health of river species and ecosystems (see Appendix 1). This knowledge will be crucial in guiding society toward ways of managing water that optimize nature's long-term provision of services while also meeting other human water demands. But realizing such improvement will require that water planners and managers do a much better job of incorporating scientific knowledge into their decisions and activities. To date, only a small number of state, provincial, or national governments are utilizing this scientific information about flow-ecology relationships in their water-management decisions. Of the government regulations that do attempt to address these issues, only a few reflect current scientific knowledge.

Consequences for River-Dependent People

Ecosystem services are defined as a variety of culturally and socially valued goods and services that human society derives from natural ecosystems. Freshwater ecosystems (which include rivers, lakes, streams, marshes, swamps, other wetlands, estuaries, aquifers, and deltas) provide a wealth of food and fiber, water purification, fish and wildlife habitat, tourism and recreational opportunities, shipping routes, and opportunities for cultural and spiritual renewal. The full range of services provided by healthy freshwater ecosystems, which require adequate river flow, has begun to be understood only in the last several decades (see Appendix 2).

Just as species evolve in response to variable environmental conditions, human cultures have evolved and adapted to the availability of resources and services provided by natural ecosystems. The availability of fish and other sources of food, reeds and timber for use as building materials, or the reliability of annual floods to supply moisture and nutrients that support floodplain agriculture or grazing have shaped and sustained human cultures around the world. As many as two billion people across the globe depend on fish as their primary source of protein, with some regions particularly reliant on fish due to the fundamental social and economic role of fisheries. Moreover, the genetic and chemical components of aquatic species may offer humans invaluable pharmaceutical and other benefits. Over many generations, the well-being, livelihoods, spiritual beliefs, and cultural practices of local communities have become intimately tied to river ecosystems.

When we alter river flow too much, everyone that depends on the river for their livelihood, recreation, or other cultural or spiritual values is harmed. This harm is precisely what the Millennium Declaration seeks to prevent through its environmental sustainability goal. Thus far, too little attention has been paid to the impact of poorly planned management and use of water. The practice of sustainable water management will require that water users and managers do a much better job of assessing their potential to harm the full array of values humans derive from healthy freshwater systems.

CAN CERTIFICATION PLAY A ROLE?

Certification programs have emerged as powerful tools to influence business practices and respond to consumer preferences. For example, certification programs for forestry practices are positively influencing the way that timber products are grown and harvested, and seafood certification programs are helping to push the adoption of sustainable harvesting practices for marine fisheries. Consumers of these products are becoming increasingly attuned to certification labeling and expressing their environmental and social values through their purchases.

A water-certification program can serve myriad purposes. To attain the performance standards set by a certification program, a business, water utility, or dam operator may need to reduce its water (and associated energy) use substantially, leading to cost savings. Or it may need to reduce its pollution discharge, thus lowering its vulnerability to regulatory action and possible legal fees. Or it may need to explore ways to manage its dams in a manner that does not impact the river downstream and the people that depend on the river's bounty.

Because certification can bolster a company's reputation for social responsibility and environmental sustainability, companies can also strengthen their social license to operate by becoming certified. These are important considerations for investors looking to minimize their investment risk, because a company that behaves in an environmentally and socially responsible manner is a company that is less likely to experience delays in gaining regulatory approval or costly disruptions in production or operations. Certification has also been shown to attract socially and environmentally concerned consumers, a rapidly growing sector of society, thereby enhancing a company's profits.

The ability of any sustainability-oriented certification program to reduce or prevent a negative impact on ecosystems and the associated human values ultimately depends on the criteria for certification. In essence, certification criteria become the rulebooks for sustainability. In the absence of adequate government regulation of water use and dams, these rulebooks are of utmost importance in defining sustainable practices in water-resource management and elevating public awareness about the social and environmental impact associated with unsustainable water use. These rules are also developed through consensus-building stakeholder processes that engage water users and other interested parties with a broad range of perspectives and expertise, thereby ensuring that the standards are both practical and attainable while also moving toward water sustainability.

Two emerging certification programs—one focused on large water users and the other targeted at hydropower dam projects—are profiled below. Each program is led by a team of well-known, respected, and influential organizations and collaborators, which are listed in Appendix 3.

These organizations, the Alliance for Water Stewardship (AWS) and the Hydropower Sustainability Assessment Forum (HSAF), are facilitating discussions with diverse water stakeholders about performance standards. The stakeholders include corporations, investors, nongovernmental environmental and social organizations, governments, academics, and other interested parties. It is important to note that neither program intends to become the organization that implements certification. They have formed, rather, to develop best-practice standards that are rooted in science and, in the case of AWS, to develop a business plan and funding sources to launch a new certification organization. Furthermore, it is important to clarify that the organizations presently represented in HSAF do not all necessarily agree about the eventual use of the standards they are developing. While some of the parties have clearly expressed their intent to create a certification organization, others are simply interested in creating a measurement tool for the hydropower industry for assessing the sustainability of a project on a voluntary basis.

While it is premature to speculate in any detail about the likely standards to emerge from these programs, it seems certain that both will address some of the key issues highlighted in this paper. Both programs will require certification applicants to demonstrate that they have thoroughly assessed the implications of their water use or of the dams they build on the quantity and quality of water flow, as well as the potential ecological and social harm associated with these hydrologic modifications. Both programs have recognized the critical importance of conducting this assessment on an appropriate spatial scale. The program the AWS is designing to certify large water users will require those users to evaluate the entire watershed area or aquifer supplying their water, and the cumulative influence of all other water uses and landscape changes on water quantity and quality. Similarly, the draft assessment protocol prepared by the HSAF addresses the potential for there to be an impact upstream and downstream of dam locations; for planned dams, the protocol would also require applicants to consider whether their dam is being placed in the location that will be least damaging to the environment and to people.

Both programs will require applicants to provide detailed information about their existing or proposed operations, so they will often have to implement their own data-collection programs to fill in the gaps of existing government programs. Additionally, both programs will explicitly require that applicants assess the potential risk of their activities to ecosystem health, social conditions, and the business operations associated with climate change.

In developing their best-practice standards, both programs will likely include a mix of what might be termed "process-based" versus "outcome-based" standards. For example, a process-based standard might require that the applicant submit an operational plan that addresses water availability, cumulative uses of water in the watershed, and the implications of climate change. An outcomes-based standard under consideration by the AWS is an assessment of the degree to which river flow has been altered by the applicant's water use and the cumulative alteration caused

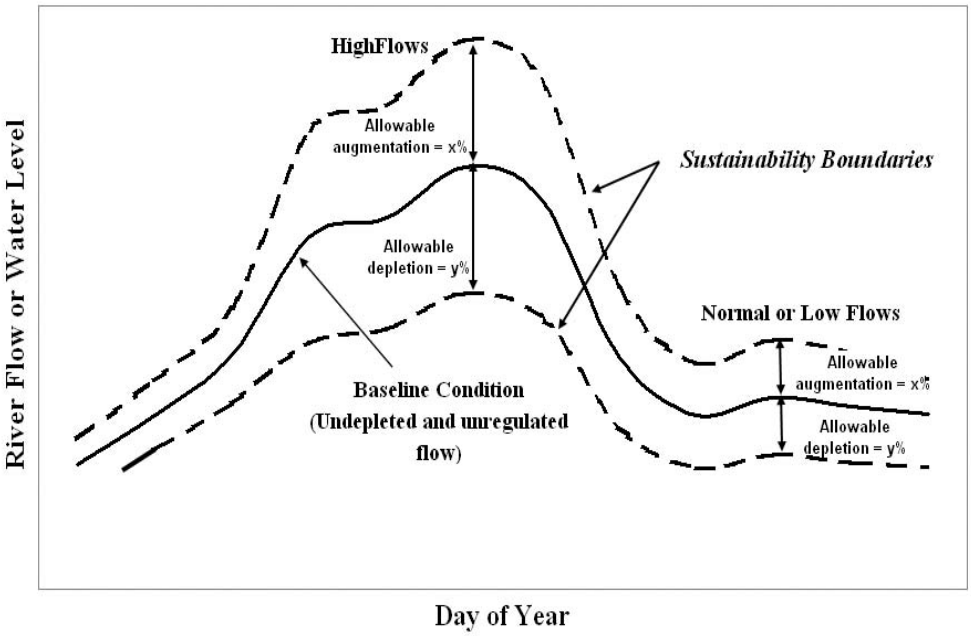

Figure 3. Sustainable River Flows

by all water users in the watershed. Such an outcomes-based standard could focus on limiting the degree to which natural river flow conditions have been altered or require that water levels be maintained within targeted "sustainability boundaries," as illustrated in Figure 3.

The Alliance for Water Stewardship

The Alliance for Water Stewardship is designing a water-certification program to foster the adoption of business practices that will improve social and environmental sustainability in water use globally. The stated mission of the AWS is to "promote responsible use of fresh water that is both socially beneficial and environmentally sustainable." This program will target two primary audiences: (1) companies that use significant quantities of water in their operations, such as manufacturing, beverage production, mining, agriculture, or energy production; and (2) water utilities that supply water to urban areas and villages.

This certification program will ultimately be administered by an independent nonprofit organization that will oversee the auditing of applications from interested businesses and utilities to determine whether they qualify for certification. The AWS performance standards will address issues of watershed protection, water-use efficiency, long-range planning, protection of a river's water flow and water quality in freshwater ecosystems, and social justice.

A key aspect of the AWS standards will be measuring the water footprint of interested businesses and utilities and setting standards that drive companies to reduce the size and impact of their water footprint. Importantly, the AWS anticipates requiring applicants to calculate their water footprint for both direct and indirect water use. The full water footprint of a business consists of its direct water use for production, manufacturing, and supporting activities, and the indirect use of water in its supply chain. A primary purpose of the water-certification program will be to encourage businesses and water utilities to minimize their water footprint. This can be accomplished by implementing water-conservation, efficiency, and treatment measures to reduce their consumption and pollution of water and, if appropriate, by implementing hydrologic restoration activities with other land and water users in their watersheds to reduce the cumulative impact.

To qualify for water certification, the Alliance for Water Stewardship anticipates that applicants will be required to measure their direct water footprints, along with other physical and chemical characteristics (such as background water availability and quality), in the local watersheds in which they operate. The same measurements will be taken in other watersheds affected by their supply chain, whenever those watersheds can be identified. The AWS recognizes that for complex supply chains and certain products, it will be impossible or impractical to identify the source watershed in which each component of the chain was produced, in which cases only the country or region of origin can be identified.

The Hydropower Sustainability Assessment Forum

The Hydropower Sustainability Assessment Forum was initiated in 2007 after a meeting between the World Wildlife Fund, The Nature Conservancy, and the International Hydropower Association (IHA) at which these organizations discussed their mutual interest in strengthening the content of sustainability standards that had previously been developed by the IHA. The three organizations agreed on the need to broaden stakeholder input on hydropower standards, particularly with respect to social, environmental, and economic interests. The HSAF members are government representatives of developed and developing countries, the hydropower sector, social and environmental NGOs, and the commercial and development banks.

Currently, the HSAF members are jointly reviewing and recommending enhancements to the IHA Sustainability Assessment Protocol, which was developed as a measurement tool to assess the social, environmental, and economic performance of hydropower projects and operating facilities.[4] The Protocol is used to assess a hydropower project at any stage in its life cycle against the sustainability criteria, with a systematic approach to scoring sustainability performance based on a review of objective evidence.

The HSAF aims to produce a draft Hydropower Sustainability Assessment Protocol in 2009, and the final Protocol will be ready by early 2010, after a period of consultation and pilot testing, . The HSAF will then focus on next steps for the

Protocol, including the potential for developing an independent certification organization.

CONCLUSION

As use of the planet's water resources intensifies, the potential for it to have an increasing impact on natural ecosystems and human communities is growing rapidly. Poor populations are disproportionately vulnerable, particularly because they are often located in countries that lack adequate water-governance mechanisms and systems, and because they often depend directly upon the water, food resources, and other goods supplied by healthy freshwater ecosystems.

The Millennium Declaration stands as a beacon for poverty alleviation around the world, but realizing its aspirations will require addressing many shortcomings in the way that water resources are presently being managed. Of particular concern is the fact that current water use is unsustainable in the vast majority of the watersheds being exploited for human use. The Millennium Declaration appropriately acknowledges that widespread adoption of sustainability principles and practices is urgently needed. At the same time, the challenge of meeting the needs of poor populations will require considerable additional development of water resources. Hence, to achieve the Millennium Development Goals, we will have to use the world's water supplies even more heavily while at the same time substantially restoring the health of many freshwater ecosystems.

Most governments are woefully unprepared and incapable of leading the necessary advances toward these water-use goals. In this vacuum, nongovernmental interests and professional water societies are stepping into the breach and tackling the difficult task of formulating sustainability standards that define "best practices" in water use and management. They are creating certification programs to incentivize the voluntary and widespread adoption of these sustainability practices. The fate of the planet's freshwater ecosystems and the world's poor may very well depend on their success.

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1. United Nations *Millennium Declaration*, resolution adopted by the General Assembly on September 18, 2000.
2. EPA 2009. *National Water Quality Inventory: Report to Congress.*
3. WWF-UK 2008. *UK Water Footprint: The Impact of the UK's Food and Fibre Consumption on Global Water Resources.*
4. The IHA Sustainability Assessment Protocol is available at http://www.hydropower.org/sustainable_hydropower/IHA_Sustainability_Assessment_Protocol.html.

Appendix 1.

Flow Level	Ecological Roles
Low (base) flows	**Normal level:** • Provide adequate habitat space for aquatic organisms • Maintain suitable water temperatures, dissolved oxygen, and water chemistry • Maintain water table levels in floodplain, soil moisture for plants • Provide drinking water for terrestrial animals • Keep fish and amphibian eggs suspended • Enable fish to move to feeding and spawning areas **Drought level:** • Enable reproduction of certain floodplain plants • Purge invasive, introduced species from aquatic and riparian communities • Concentrate prey into limited areas to benefit predators
Higher flows	•Shape physical character of river channel including pools, riffles •Determine size of stream bed substrates (sand, gravel, cobble) •Prevent streamside vegetation from encroaching into channel •Restore normal water quality conditions after prolonged low flows, flushing away waste products and pollutants •Aerate eggs in spawning gravels, prevents siltation •Maintain suitable salinity conditions in estuaries
Large floods	•Provide migration and spawning cues for fish •Trigger new phase in life cycle (e.g., insects) •Enable fish to spawn on floodplain, provide nursery area for juvenile fish •Provide new feeding opportunities for fish, waterfowl •Recharge floodplain water table •Maintain diversity in floodplain forest types through prolonged inundation (i.e., different plant species have different tolerances) •Control distribution and abundance of plants on floodplain •Deposit nutrients on floodplain •Maintain balance of species in aquatic and riparian communities •Deposit gravel and cobbles in spawning areas •Flush organic materials (food) and woody debris (habitat

Appendix 2a.

Service category	Service provided	Key flow related function	Key Environmental Flow component or indicator
Production	Water for people - subsistence/rural and piped/urban	Water supply	Floodplain inundation
	Fish/shrimp/crabs (non-recreational)	Habitat availability and connectivity, food supply	Instream flow regime, floodplain inundation, flows sustaining riparian vegetation
	Fertile land for flood-recession agriculture and grazing	Supply of nutrients and organic matter, moisture conditions in soils	Floodplain inundation
	Wildlife for hunting (non-recreational)	Habitat availability and connectivity, food supply	Floodplain inundation, flows sustaining riparian vegetation
	Vegetables and fruits	Supply of nutrients and organic matter, seasonality of moisture conditions in soils	Floodplain inundation, flows sustaining riparian vegetation
	Fiber/organic raw material for building/firewood/handicraft	Supply of nutrients and organic matter, seasonality of moisture conditions in soils	Floodplain inundation, flows sustaining riparian vegetation
	Medicine plants	Supply of nutrients and organic matter, seasonality of moisture conditions in soils	Floodplain inundation, flows sustaining riparian vegetation
	Inorganic raw material for construction and industry (gravel, sand, clay)	Sediment supply, transportation and deposition (fluvial geomorphology)	Instream flow magnitude and variability

Appendix 2a.

Service category	Service provided	Key flow related function	Key Environmental Flow component or indicator
Regulation	Chemical water quality control (purification capacity)	Denitrification, immobilization, dilution, flushing,	Floodplain inundation, instream flow regime,
	Physical water quality control	Flushing of solid waste, flushing/retention of sediment, shading	Floodplain inundation, instream flow regime, flows sustaining riparian vegetation
	Flood mitigation	Water retention capacity	Floodplain inundation, flows sustaining riparian vegetation
	Groundwater replenishment (low flow maintenance)	Groundwater (aquifer) replenishment	Floodplain inundation
	Health control	Flushing of disease vectors	Instream flow regime, water quality
	Pest control	Habitat diversity, disturbance and stress	Instream flow regime
	Erosion control (riverbank/bed and delta dynamics)	Healthy riparian vegetation, erosion, transportation and deposition of sediments	Flows sustaining riparian vegetation
	Prevention of saltwater intrusion (salinity control)	Freshwater flow, groundwater replenishment	Instream flow regime
	Prevention of acid sulphate soils development	Groundwater replenishment	Floodplain inundation
	Carbon "trapping" (sequestration)	Accumulation of organic material in peat soils	Floodplain inundation
	Microclimate stabilization	Healthy ecosystems	Floodplain inundation, flows sustaining riparian vegetation

Appendix 2c.

Service category	Service provided	Key flow related function	Key Environmental Flow component or indicator
Information	Recreation and tourism (incl. fishing and hunting)	Presence of wildlife, aesthetic significance, good water quality	Site specific
	Biodiversity conservation	Sustaining ecosystem integrity (habitat diversity and connectivity)	Natural flow regime
	Cultural/religious/historical/symbolic activities	Site specific	Site specific
Life support	The prior existence of healthy ecosystems	All	Natural flow regime

Appendix 3.

Alliance for Water Stewardship (AWS)		Hydropower Sustainability Assessment Forum (HSAF)	
Organization	**Primary Interest Area**	**Organization**	**Primary Interest Area**
The Nature Conservancy (NGO)	Environmental (nature conservation)	Government of China	Developing country interests
World Wildlife Fund (NGO)	Environmental (nature conservation)	Government of Zambia	Developing country interests
Water Stewardship Initiative (NGO)	Environmental and social	Government of Iceland	Developed country interests
Pacific Institute (NGO)	Environmental, social, water policy	Government of Norway	Developed country interests
Water Witness (NGO)	Social	Government of Germany	Developed country interests
Water Environment Federation (professional society)	Water science and technology	The Nature Conservancy (NGO)	Environmental
European Water Partnership (quasi-public entity)	Environmental, social, water governance	World Wildlife Fund (NGO)	Environmental
		Oxfam (NGO)	Social
		Transparency International (NGO)	
		Equator Principles Financial Institutions Group (private banks)	Economic
		World Bank (multi-lateral bank)	Economic
		International Hydropower Association (professional society)	Hydropower

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