WEEK SIX: HOW DO WE MANAGE WATER SYSTEMS? | ESSAY TWO

Water Management and Sustainability

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As we learned about the Colorado River early in the course, the pattern in the American West has been to build infrastructure to sustain economic growth. However, there and elsewhere, the challenges of managing water sustainably require a more comprehensive approach. Conservation initiatives and new technologies both hold promise.

The Colorado River Revisited: How Will the West Be Watered?

Reflecting new agency priorities for environmental protection that include moving away from large water project development, the U.S. Bureau of Reclamation has shifted to resource management. In the Colorado River Basin, initiatives include conservation measures such as employing more efficient irrigation techniques and improving existing infrastructure, economic incentives that promote savings and reduce demand, and employing technology to recycle and reuse water.

Conservation Opportunities

This graph shows the impact of water conservation policy on indoor water use in California from 1980 to 2020. The top line shows a projection of pre-1980 conditions on the following 40 years; the middle line shows the current mix of efficient and inefficient conservation solutions; the bottom line shows an estimate of further reduction of indoor water demand. ©Pacific Institute

Conservation

Arizona’s overall allotment of water, as per the Law of the River, remains fixed at 2.8 million acre feet. As in much of the basin, a limited amount of water must be divided among users who range from farmers to high-tech manufacturers to city-dwellers.

Agriculture offers the most significant opportunities for conservation. One study estimates that upgrading half of Arizona’s major irrigated systems to drip or other low-pressure, low-volume techniques could save on the order of 445,000 acre-feet of water per year. Combined with other approaches like switching from water-intensive crops such as alfalfa, cotton, and wheat to high-value, less thirsty crops such as vegetables, this could save approximately 1.24 million acre-feet (maf) per year, which is comparable to the Lower Basin’s annual groundwater overdraft (when groundwater withdrawal exceeds recharge).
Urban water conservation will also become integral to regional management. A permanent combination of efficiency standards and regulations, voluntary retrofits with water-saving plumbing fixtures, and public outreach efforts that promote water-saving technologies and behaviors should curb domestic consumption. Tucson, for example, used higher water rates, public education, and revised plumbing and landscaping codes to stabilize its daily per capita water use. However, whether or not conservation measures are in place, population growth will increase demand. This complex and potentially politically difficult challenge calls for urban planning, growth-management tools, and a re-evaluation of how the Colorado River’s water is allocated.

**Economic Incentives**

The “use it or lose it” mentality long in place in the Southwest is a major obstacle to resource management. Properly designed water-pricing structures, combined with groundwater depletion taxes, could promote efficiency and reduce demand.

Market-based water management strategies are one such tool. Voluntary water-rights transfers could move water from relatively low-valued uses to higher-valued ones—from agricultural districts to municipalities, for example. To address any concerns on the part of water rights owners that temporary transfers could lead to permanent forfeiture of those rights, the market must clearly delineate all stakeholders’ rights.

Transfers have already occurred in some parts of the basin, as between the Metropolitan Water District of Southern California and regional irrigation districts. However, the market is still developing. In the future, Colorado River water transfer users could pay surcharges (in form of money or water) or public trust fees to the appropriate water management agency. These surcharges could be used for environmental restoration and maintenance. For example, a 5 percent water surcharge on a voluntary transfer of 40,000 acre-feet/year would free up 2,000 acre-feet to restore eroded sandbanks.

**Technological Solutions**

Some water managers are turning to innovative systems to meet the needs of their growing cities. The Prairie Waters Project of Aurora, Colorado, draws water from the South Platte River. The water passes through a wastewater treatment facility after use and goes back into the river. Downstream from the facility, the city is drilling wells to pull water up through the riverbed, using the gravel and sand as a natural filter. After being treated with chemicals and UV light, and then filtered, the extracted water is pumped back to the city’s taps, completing the loop.

Creative approaches like the Prairie Waters Project will be increasingly necessary as water stress increases. A solution like Aurora’s reduces pressure on water supplies, but it may only be replicable in municipalities that can afford the necessary infrastructure and long-term planning. Other solutions include water-saving appliances and industrial processes that reduce consumption, such as replacing factory cooling systems that use water once with ones that recirculate the water.

While the history and ecology of the Colorado River Basin make it unique, the system also illustrates many of the challenges faced by water managers all over the world. As demands mount and the tradeoffs grow ever more challenging, sound water policy will require an integrated planning process that’s predicated upon innovative thinking and consensus-building.

**Water Purification Process**

The Prairie Waters Project will draw water through a natural sand and gravel filter into a protected aquifer. The treatment facility softens the mineral content of the water, disinfects it with ultraviolet light, and filters it through activated charcoal before it is piped back to Aurora for reuse. ©Aurora Water

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As we’ve seen in examples from all over the world, the sector-by-sector, top-down approach to water resource management is inherently unsustainable. Agriculture consumes water on a massive scale and often its runoff pollutes, leaving less clean water for cities and industries. Municipal and industrial wastewater can contaminate waterways, damaging ecosystems. Water left in rivers and lakes to conserve and protect wetlands and fisheries leaves less for cropland. An alternative approach, based on the concept that the many different uses of water are interdependent and must all be taken into consideration in management decisions, has been gaining acceptance worldwide.

This holistic or cross-sectoral approach is known as “integrated water resource management,” or IWRM. It acknowledges that all demands upon this resource—upstream and downstream—are interconnected and must be considered in management decisions. IWRM also involves using water more efficiently, by reducing demand and improving conservation efforts. Lastly, IWRM applies a cross-sectoral approach to decision-making, with full stakeholder input in planning and management, including legitimate claims by future generations.

The foundation of IWRM is the need to manage resources at the watershed level: the entire area served by all the rivers and aquifers that drain into a particular body of water and on into inland lakes or the sea. Everyone lives within a watershed and can affect it. A watershed management perspective seeks to balance the demand for clean water against increasing pressure from population growth and economic development, which may threaten ecosystem services and water quality. Ideally, a comprehensive watershed management plan mobilizes communities and individuals, and gains broad acceptance at the national level.

**IRWM Must Involve Stakeholders At All Levels**

Integrated water resource management is also a complex and potentially contentious process that involves many stakeholders with competing views about water use. One successful example is the Tennessee Valley Authority (TVA), which was established in 1933. The TVA operates a wide variety of water, power, economic development, and environmental programs within the Tennessee River watershed, which spans seven southeastern states. It’s had a long history of involving constituencies that range from state and local governments to industries and environmental advocates.

Another example is the Murray-Darling Basin Authority (MDBA, formerly the Murray-Darling Basin Commission), which coordinates management of Australia’s largest river system (23 rivers and a number of groundwater systems in four states and a territory). A pioneer in developing integrated water management policy, the authority was established in the late 1980s to address severe ecological degradation and the overallocation of water for irrigation in this generally semi-arid region. States and individuals can trade water rights and settle disputes through an established procedure. The governance structure involves stakeholders at all levels, including environmental groups, indigenous people, and farmers. The MDBA has reduced salinity in the basin, introduced water-withdrawal caps, and reduced point-source pollution. In the face of a severe, multiyear drought, however, the MDBA faces tough challenges ahead.

**IWRM Can Operate At All Scales**

IWRM initiatives at the local level, both urban and rural, are showing that even in arid places, water can be used much more efficiently. Furthermore, when communities manage freshwater resources better, soils and forests can also benefit, agricultural production can increase, and public health can improve. A program in the main agricultural area of Burkina Faso, called Six-S (for *Se Servir de la Saison Sèche en Savane et au Sahel*—“Using the Dry Season in the Savannah and in the Sahel”), is a good example. Founded in the 1970s in the aftermath of a severe famine, this grassroots group has worked on reforestation, small-scale irrigation, basic hygiene, and erosion control initiatives. While control and oversight are centralized, most of the decision-making power is in the hands of members at the village level. However, adequate funding and capacity can be a key limitation for initiatives that fail to engage and empower local community members as successfully as Six-S.

Integrated water resource management requires institutional capacity, including the creation of cross-sectoral data collection and monitoring systems. This necessitates that national, regional, and local agencies be technically and administratively competent, and capable of responding to changing political and environmental conditions. These challenges increase along with watershed size and complexity. Water economies in many developing countries are largely informal, with varying levels of regulation over how water is delivered and how wastewater is collected. In these countries, IWRM efforts are most effective when focused on improving access to clean water and lowering the costs involved in market exchange.

**Applying IWRM to Transboundary Water Management**

Water is a geopolitical resource: Nations often depend on flows from neighboring countries, or rely on virtual water transfer. Transboundary waters, both surface and groundwater, are those shared by two or more nations. There are 268 transboundary river basins worldwide, and approximately 40 percent of the world’s population depends on these shared river basins for water. In November 2005, the 2,000-kilometer (1,200-mile) Songhua River in northeastern China made headlines when a chemical plant in Jilin spilled massive amounts of the toxic chemical benzene, creating an 80-kilometer (50-mile) noxious slick. As the chemicals oozed toward the sea, cities that drank from the Songhua were forced to cut off supplies, leaving millions to fend for themselves. As the slick passed over the border to the Russian city of Khabarovsk, it created an international incident.

The Songhua incident is a reminder that in Asia—as everywhere else in the world where water is shared—cooperation between neighboring countries is essential.

During the past 20 years, IWRM has gained visibility as the best way to balance intensifying demands on the world’s water. This watershed-based system is a challenge for China, where massive watersheds require a vast network of institutional connections. It also calls for collaborative decision making that may be difficult to integrate into China’s current regulatory process. However, the country has made progress in implementing IWRM in some of its basins, in particular that of the Yellow River, which is home to 172 million people. The Yellow
River Conservancy Commission is tasked with allocating water from the country’s second-longest river throughout the basin, and addressing continued problems of scarcity. Adequately funded and supported by the government, the Yellow River Conservancy Commission is the country’s most successful example of IWRM implementation to date.

New Tools Inform Management Decisions

At the Museum’s Center for Biodiversity and Conservation, we’ve seen a number of tools and data types that are making it increasingly possible to visualize and monitor changes in the distribution of water at local, regional, and even global scales. These changes can include everything from the reduced flow in the Colorado River Delta to wetland loss in the Niger valley and pollutant loading in Indonesia’s Citarum River. These tools include:

- **Remote sensing**
  The process of using sensors on platforms like satellites, aircraft, and buoys to collect data about an object or phenomenon. For example, satellite images of river deltas can be used to monitor how much sediment is emptying into the ocean. Since many freshwater ecosystems change regularly (for example, river courses are frequently altered by erosion and wetlands may change seasonally), timely and repetitive monitoring can inform long-term decision making. If water managers are deciding about the best way to restore a wetland, for example, it can be invaluable to review historical remotely-sensed images.

- **Geographic information systems (GIS)**
  GIS software allows water managers and scientists to manipulate, manage, and analyze spatial data, which can then be visualized and interpreted to reveal relationships, patterns, and trends. GIS can be used to locate, quantify, and model pollution sources; to identify wetlands and other ecosystems that may need protection; and to monitor the dramatic impact of dams upon upstream and downstream flow regimes. Wisconsin’s River Alliance has been using GIS to rank small dams in the Lake Michigan and Lake Superior watersheds according to the potential benefit of removing each one. For this study, natural resource managers collected data on factors that included fisheries habitat, dam distribution, water quality, and the potential restoration of connections between waterways.

- **Modeling**
  This is the process of generating conceptual, graphical, or mathematical models to understand the dynamics of a complex real-world system. Practically any system can be modeled, from a biological one such as small population of fish to physical systems such as a lake or the atmosphere. For example, water managers at the Bureau of Reclamation have created a massive hydrological model of the Colorado River, using data that includes everything from reservoir storage to water withdrawals. Managers can use this model to explore how changes in management would affect many different aspects of the river.

New Fields of Study

Our search for knowledge continually drives the new fields and disciplines that improve our understanding of the natural world. Examples include a growing understanding of evolutionary relationships as well as the emerging field of ecosystem valuation, both of which are informing conservation decisions.

- **Systematics and conservation genetics**
  Systematics is the study of the evolutionary history of life on Earth. Systematists provide the basic measure of biodiversity by identifying species and classifying them in terms of their relationships to other organisms, both living and extinct. The tools and data of molecular systematics help conservationists understand which lineages are especially valuable from an evolutionary point of view, and also shed light on the demographic and genetic structure of populations—considerations that can guide management and conservation decisions.

For example, these tools were recently used to inform freshwater fish conservation efforts in South Africa. The only fish endemic to Lesotho, the Maluti minnow (*Pseudobarbus quathlambae*), was already under threat from introduced species in headwater streams when it was discovered in 1938. Rediscovered in the 1970s, the minnow was classified as critically endangered. When a team of scientists assessed the impact of proposed dams, it found that different populations along the waterway were evolutionarily distinct, and therefore should be managed independently for conservation purposes. As a result, sanctuary streams protected from the dams were created to conserve these populations.

- **Ecosystem valuation**
  This emerging field enables policymakers to frame human impacts in economic terms, so that decisions can take into account the estimated dollar value of degrading or restoring these essential services. For example, the restoration of a degraded floodplain in Cameroon was shown to generate tangible economic benefits for the extremely poor local human population. By indicating the relative value of ecosystem services in general, ecosystem valuation may help agencies set priorities for conservation or restoration projects, and maximize the environmental benefits of these projects.

Ensuring Enough to Go Around

If supplies are well-regulated on both national and international levels, even a drier, more crowded world should have enough water to meet its needs. Sound water management policy requires seeking synergies and choosing appropriate tradeoffs. It also requires distinguishing between “fire fighting” (responding to the urgent issues of the day) and long-term strategic development. Using less water for more purposes and reusing it wherever possible can lessen the need for tradeoffs by making the most of the same volume of this invaluable resource. After all, we all live “downstream” from one another, and water is essential to the health of all species.
A River Across Centuries

Lanzhou was once a major stop on the Silk Road in northwest China, and today is still a major hub for trade and commerce, thanks in large part to the Yellow River. However, the surrounding Gansu Province struggles to provide enough water infrastructure for agriculture and industry needs. IWRM is one solution for the region. ©Flickr / Lens Fodder

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NGM: Australia’s Dry Run »
An article about the drastic changes to the Murray-Darling Basin in Australia.

Tennessee Valley Authority »
Learn about the governmental agency providing energy, environmental protection, and economic development to the Tennessee Valley.

UNEP: Songhua River Spill Report [PDF] »
The joint report from the United Nations Environment Programme and the Chinese government about the chemical spill in 2005.