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Water and Sustainability: Reflections from the Western United States

Why talk about a shortage of supply? Why not talk instead about a longage of demand?
—from Hardin (1986)

Looking out the window at a grey, dripping sky, another "spring" day on the wet side of the Pacific Northwest, it is hard to imagine that water could be anything but sustainable. Having grown up in New Mexico, it seems to me that the only thing the Northwest sustains is entirely too much water. So this is a problem for other places, places like New Mexico, right?

Yes, for sure. But it is a problem for the Northwest too. And it is worth considering that a problem in other places, faraway, can all too easily become a problem here.

Sustainability

What do we mean when we speak of water and sustainability – certainly we include having sufficient clean water for our daily needs: keeping our water taps flowing with clear, safe-to-drink water; keeping our showers and toilets running; maybe watering the garden or having a sprinkler for the kids to run through on a hot summer's day. But these domestic uses account for only about 10% of the water used in the 11 Western states whereas irrigation accounts for approximately 85% of the water withdrawn (Hutson 2004). Irrigation is also the dominant use of water worldwide and irrigated agriculture supplies some 40% of the world's food (Vörösmarty and Sahagian 2000). So water sustainability also means having enough to eat. And in a world focused on, "peak oil" and, "reducing our carbon footprint," a world in which we must become ever more reliant on renewable sources of energy, what could be more renewable than hydroelectric power? So water sustainability also means a light to read by and the (electrical) power behind the World Wide Web. But then there is also the natural world. Lichatowich titled his book *Salmon Without Rivers,* capturing an image that no Northwesterner would want. So water sustainability is more than just human needs, it is about salmon, ducks, and waterfalls. In fact, water sustainability is about balancing all of our needs and wants in an uncertain future.

Population Growth and Human Migration

There is precious little fresh liquid water on the Earth's surface (~0.0075% of the Earth's water), and of the water reasonably available to society, humans already capture and use more than half (Postel et al. 1996, Vörösmarty and Sahagian 2000). But sustainability is not an argument about "half full" or "half empty." Rather, simple averages hide extreme disparities. For example, the Amazon basin which accounts for ~15% of the annual global runoff contains only 0.4% of the Earth's human population (Postel et al. 1996). In contrast, India, which is about half the size of the Amazon basin, has 16% of the Earth's population but only 4% of the annual global runoff (see http://www.nih.ernet.in/water.htm, accessed on 23 June 2010). The daily struggle just to find enough water for drinking and cooking consumes the lives of millions of people, who must walk long distances to find water, carry it by hand, and live on less than 20 liters a day. And for many, finding water that is safe to drink is impossible (Rosenberg 2010). This lack of ready access to clean water limits opportunities and economic development for millions of people.

Population growth and water supply issues are not as extreme in North America as in many other parts of the world. Still, in many parts of the arid

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West, surface water supplies are fully allocated and groundwater sources are being used faster than they are replenished. The dry and sunny Western states also have the highest population growth rates in the United States. The Colorado River is a case in point, supplying water to seven states, of which California and Arizona both rely heavily on the Colorado River for a significant portion of their water supply. The interstate compact governing water distribution allocates 19.1 billion m^3 of water among the 7 states and 1.8 billion m^3 for Mexico. Since it was signed in 1922, estimates of annual average discharge have been revised downwards to about 16.7 billion m^3. Moreover, the Compact did not explicitly allocate water for Native American tribes nor did it consider environmental needs. Recent drought in the Colorado River basin has challenged water distribution systems, placed increased pressure on aquatic ecosystems, and focused increased attention on long standing laws and precedents that govern use of water in the basin.

Over the next few decades, human population growth is likely to have a much bigger impact on water supply than will climate change (Vörösmarty et al., 2004). Water stress will contribute to the growing tide of global environmental refugees, population migration, and geo-political instability. Closer to home, water supply will be challenged by population growth with potential impacts on regional economies and may even begin to limit growth and development. The need to solve these problems will grow more urgent in the future as pressure on water resources from population growth is exacerbated by water pollution, climate change, and drought.

Pollution

Although humans capture more than half the water available to us, our actual consumptive use is much smaller. In fact, most of the water withdrawn is later returned to rivers and streams. For example, irrigation is the primary use of withdrawn water in the western United States, but some 19% of irrigation water seeps back into the ground from irrigation canals (conveyance losses) and irrigation drainage water returns 20% of the withdrawn water to streams and rivers (Anderson and Woosley 2004). Water quality is often degraded through human uses. Passage of the 1972 Clean Water Act marked a watershed moment in the management of surface water quality in the United States. Since then, point sources of water pollution have been substantially cleaned up or eliminated with subsequent improvement in the nation's water quality.

Non-point source pollution poses major challenges today. For example, groundwater recharge in intensively farmed areas is often polluted with nitrate and other agricultural chemicals creating problems for domestic supplies dependent on groundwater sources. Both surface runoff and groundwater flows from farmlands carry residues of agricultural chemicals to rivers. Similarly, storm runoff from many cities bypasses or overflows sewage treatment plants, routing sediment, heavy metals and chemical residues from roads, parking lots, and buildings directly into lakes and rivers. The cumulative effects of these pollutants can cause substantial environmental problems.

There is also increasing attention to trace pollutants that can pass through sewage treatment plants. One group of these trace pollutants mimics hormones that regulate development in mammals (including humans), birds, and fish. These "endocrine disrupters" include medicinal products for hormone therapy and contraception (Williams et al. 2003), some pesticides, and waste from industrial processes such as the manufacture of plastics. Endocrine disrupters have shown adverse effects in biological studies and are implicated in studies of developmental abnormalities and decreased reproductive success of fish (Zeilinger et al. 2009) and there is increasing attention being paid to their potential effects on humans.

Ecosystem Needs

The combined impacts of human land-use and water withdrawals on riverine ecosystems are huge. For example, water in the Colorado River is over allocated. Even though most states use less than their total allocation, the Colorado River no longer flows to the ocean in most years. In 2001, drought sparked intense conflict over the use and allocation of water in the Klamath River basin of southern Oregon and northern California. Renewed drought in the spring of 2010 is reawakening those conflicts and putting at risk a decade of effort focused on solving conflict and restoring salmon runs. In the Columbia River basin, the combined influence of human land-use practices, including dams that generate much of the region's hydroelectricity, has spawned one of the nation's largest restoration efforts with over $3 billion spent by the year 2000 to recover stocks of Pacific salmon. Our wants and needs increasingly conflict with environmental conservation goals. Those conflicts will grow worse as the climate continues to get warmer.

Climate Change and Climate Extremes

Given the focus on climate change as the environmental issue of the day, we might assume that our biggest uncertainty facing future water supplies is climate. Certainly, climate change scenarios project growing severity of hydrologic impacts with each passing decade of the 21st century which will make it ever more difficult to meet water supply needs. Future projections are often expressed as a change in the long-term average – a 1.1°C increase in average annual temperature or a 1% to 2% increase in average annual precipitation – those are the 2020 projection for the Pacific Northwest (Elsner et al. 2009). But what about droughts and floods?

Climate change projections also suggest thinner winter snow packs for the Pacific Northwest, earlier snow melt, and increased likelihood of flooding from extreme rain-on-snow events. We build and operate dams to limit flood damage and to provide water during the summer. But, if floods and droughts become more extreme, it will be more difficult to provide protection from floods and ensure dependable supplies of water with our current infrastructure. Building more dams might be an option, but in the western United States most of the best dam sites have already been dammed, and where rivers are already over allocated, more dams will not necessarily mean more water. Further, building large dams has substantial social, economic, and ecological costs. Alternatively, operations of existing dams might be changed to more tightly regulate rivers to meet immediate human demands. But this alternative also incurs substantial ecological costs by increasing river regulation and contributing to further losses of the natural hydrologic patterns to which life in rivers is tuned.

The Next Steps

Scientists can document past changes, monitor current activities, and project future trends. Science can help identify issues, examine effects of alternative policy decisions and even suggest potential solutions. But scientists do not make the choices. Policy makers and the general public do. And people will have to face tough choices at local, regional and global scales. Our societies require enormous quantities of clean, fresh water, quantities too large to easily transport from regions of excess to regions facing shortages. Thus, we rely on natural systems to supply our fresh water. That supply is fixed. Therefore, we must find ways to work together to better manage our demands.

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