New Sources of Water - An International Challenge

Slav W. Hermanowicz
Department of Civil and Environmental Engineering
University of California, Berkeley, CA 94720-1710
hermanowicz@ce.berkeley.edu
www.ce.berkeley.edu/~hermanowicz

Water Needs and Resources

The overarching issue in water science and engineering is to meet the demand for water while at the same time maintaining an ecological balance. Through human history access to water was one of the major factors controlling growth and development. On the global scale, the overall quantity of freshwater, at about 8000 m^3/cap·yr, is more than sufficient to meet human needs. However, water resources are not distributed uniformly and the amount of *renewable* water per capita varies widely, from more than 100,000 m^3/cap·yr in Canada and Congo to less than 200 in parts of northern Africa. If a commonly accepted threshold of critical water stress of 1000 m^3/cap·yr is used, 1.7 billion people live in such stressed areas. Actual access to water of adequate quality (as opposed to its potential availability) is yet another factor controlling human life since water needs to be extracted from the environment, treated and supplied to the point of use in an organized and reliable manner. In many places sufficient natural water resources exist but they are not available to people or dramatically mismanaged. As a result, one billion people worldwide lacks sufficient access to water. Cutting this number by half in 15 years is one of the Millennium Development Goals. However, implementation of these goals and other international initiatives (like the "Water for Life" Decade, International Year of Freshwater, World Water Forum and others) produced little progress.

While water is an essential element of life, access to it, or really the lack of access, is not only a moral issue. Poor water supply degrades public health, stunts economic development and even affects the level of education. In many developing countries the burden of water provision to individual households is placed upon young women and girls who spend a lot of time and physical energy carrying water from distant sources. This occupation takes priority over schooling and deprives huge segments of population of a chance for better life including more gender equity. The economic impacts of insufficient water supplies are very severe since water is used in virtually all economic activities, from agriculture to power generation to computer chip production. The area of Tijuana in Mexico is a classic example where water limits industrial growth while the economy of Central Valley in California depends critically on water for agricultural irrigation.

In many regions, limited water supplies are shared among different countries. Such situations exist in Central America, Middle East, Central Asia and other localities. Although so far no wars have been fought for water, the underlying water limitations are a source of persistent international frictions. For example, the relations between the US, Canada and Mexico have been occasionally strained due to water issues. Even within a single country, regional conflicts are fueled over water. Northern and southern California engage in perennial "water fights" and in Spain recent conflicts over water transfers played out against the background of separatists tendencies of Catalonia.

Past Solutions

Historically and still today, water supply issues were solved by transporting water from its sources to the consumers, often over large distances through expensive infrastructures. Ancient civilizations practiced such methods and in modern times, water transportation networks of California can be considered the pinnacle of this approach. While these infrastructure-based solutions were adequate in the past, they cannot solve the current global water crisis. Construction and maintenance of dams and aqueducts are very costly. Opposition to new projects is vociferous and based on environmental, social and political reasons. The Three Gorges dam in China is probably the last example of its kind and destruction of existing dams is now seriously proposed.

New Approaches

New solutions to growing water demands will usually consist of water management, water conservation and education, financial tools, and technology. Two areas of science-based solutions probably offer the largest potential: *(i)* modification of irrigation methods for crops, and *(ii)* water desalination and reclamation.

Agriculture is the biggest global user of freshwater resources, accounting for 70-80% of total withdrawals. In addition, most of water used for irrigation does not return to its source but is "lost" through evapotranspiration. The part that is returned to surface waters or groundwater is often heavily contaminated with pesticides, fertilizers or compounds leached from the irrigated soil. At the same time, agriculture as a largest single user is commonly under pressure to yield some of its water to supply urban populations, industries and, increasingly, environmental demands. Almost all other water users can exert significant economic and political pressure to reallocate water from agriculture. While interesting and promising research is carried out on agricultural water issues in a few centers, much more can be done. The exciting areas of research include better and more economical irrigation such as subsurface techniques, reducing water demand by plants and increasing their tolerance to lower water quality (possibly through crossbreeding and judicious genetic modifications), better water retention in soil, and understanding of water transport in plants.

While water conservation techniques are very important and attract significant attention, production of fresh water from sea or brackish water could provide new sources convenient for large populations that live near the sea coast. Desalination has been practiced for decades but its wide applications were limited to areas that have virtually no water but could provide huge quantities of energy this process required. Current advances in membrane technology reduced energy consumption and brought down the costs in the developed countries to the level comparable with other water sources. Still, the costs and the technical difficulties make this technology not yet widely applicable across the globe. Similarly, water reclamation is now practiced worldwide and provides a valuable contribution to the overall water supply but is still limited in scope. Technical developments in desalination and water reclamation were hampered by empirical, *ad hoc* approach where treatment processes were "invented" without a good understanding of the fundamentals. Science came often after the development, only in an attempt to explain process limitations. New approaches should be based on the strong fundamental knowledge of chemistry, physics, nanoscience, microbiology combined with good engineering to produce breakthroughs rather than marginal improvements.

A model for such creative involvement of scientists, engineers and policy makers already exists by linking private and public resources. The Gates Foundation and the National Institutes of Health combined their efforts to identify, through an open and competitive process, Grand Challenges in Global Health. In response to over a thousand proposals, fourteen Grand Challenges were selected. In a similar fashion, a somewhat larger but still very focused coalition of private and public partners could be established to develop grand challenges in water resources with a strong emphasis on new technological solutions. Such a coalition and the associated funding would lend credibility and accountability to efforts to provide new sources of water for the future world. Implementation of the new discoveries must also be considered in view of significant challenges and diverse conditions in different parts of the world. The implementation efforts could be again modeled on the existing structure of the Millennium Challenge Corporation that links the development with sound political, economic and social policies.