EDITORIAL

Challenges in Graduate Education in Integrated Water Resources Management

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The Need for Integrated Water Resources Management

In a recent editorial, Stakhiv (2003) called for the implementation of integrated water resources management (IWRM) in the United States. Others have identified this need both globally and locally because global problems centering on water resources are pervasive. They affect political relations, public health, agriculture, development, and the environment. Particularly important examples summarized by Colwell (2002) include transboundary rivers (∼260 rivers cross national lines, resulting in potential conflict and water wars); overuse (the Yellow River in China and the Colorado River in the United States are so overused, they are dry at their mouths); lack of access to safe water for 1.1 billion people and adequate sanitation facilities for 2.4 billion people; and increasing water needs in settings of inadequate water supply. The United Nations (UN 1997; UNESCO 2003) reports that half of the developing world's population suffers from water- and food-related diseases, with 5 million people dying yearly from diseases caused by unsafe drinking water or a lack of water for sanitation. They also report that women and children in the developing world spend ∼10 million person-years of effort each year to bring household water from distant sources, time better spent on education and other activities. Long-term climate change and population growth will further stress water resources in many regions, and acceptable adaptation will only be achieved through integrated water resources management (IPCC 2001). Colwell (2002, p. 4) concluded, ''...in the 21st Century we have to develop an integrated approach across the disciplines to understand the complexity of water issues worldwide,'' and further described how complex global water issues require an approach that combines engineering with the natural, physical, and social sciences.

The United States is not immune to these global problems. Over 50% of its watersheds have either moderate or serious water quality problems (US EPA 1996a). Nearly 950 towns combine municipal wastewater and storm-water in their sewer systems, a practice which pollutes receiving waters; 44% of estuaries are unfit for fishing or swimming (Ocean Conservancy 2002); and nonpoint source pollution from diffuse land and underground sources is the primary source of pollution. Agriculture sources affect 60% of the U.S. impaired river miles, while urban runoff affects another 12% (US EPA 1996b). There are conflicts over the water rights of Native Americans, and, in 2002, half of the contiguous United States was in moderate to extreme drought (http://www.noaa.gov). A report of the U.S. National Research Council (USNRC 2001) stated that ''the progressive intensification of U.S. water scarcity in the face of competing demands for water will necessitate proactive and innovative scientific, technological, and institutional solutions....'' The report continues: ''What is needed for understanding water resources is a more holistic conceptual framework... solutions cross traditional disciplinary and societal boundaries.'' The World Bank, the World Commission on Dams, the U.S. Geological Survey, and the Global Water Partnership describe these and other problems that require integrated solutions. Integrated interdisciplinary resolution of water problems was also a major theme of the recent World Water Forum.

Why is there still a need for an integrated approach in the U.S. when water professionals have been discussing the integration of disciplines since at least the 1960s (Major 1977)? One reason is that the planning process has favored ''integrated multidisciplinary'' approaches, which involve people working independently from their disciplinary perspectives and then, only later, attempting to integrate the results. An example of the inadequacy of this approach is the environmental impact assessment process where engineering analysis is first performed, and environmental and social impact assessment is later used to adjust and improve the engineering analysis. Stakhiv (2003) suggests a variety of other reasons for the lack of IWRM in the U.S., but most notably the lack of a national water policy. Another reason for the lack of IWRM in the U.S. corresponds to the thesis of this editorial: that there appear to be few, if any, graduate programs in the U.S. that focus on IWRM.

Graduate Education in Integrated Water Resources Management

The founding principle of an IWRM graduate program should be that it include *all* disciplinary perspectives relevant to water management. Water management is now recognized as a socio-economic, institutional, and ethical challenge as much as it is a biophysical and engineering challenge. Thus IWRM graduate programs should be open to all relevant disciplines and be dedicated to educating people skilled in one discipline who can use multiple disciplinary perspectives and tools at the outset of the analysis of water problems. Graduate programs must emphasize the need for teamwork to develop solutions jointly using the rigorous methods and tools that come from the array of disciplines needed to solve such problems. While a solid grounding in one discipline is needed to participate effectively in IWRM, students must also have rigorous exposure to the range of methodological tools used by different specialties. We believe that these tools and approaches can be characterized by the following pillars of IWRM and taught via courses using traditional methods as well as active pedagogic approaches, including gaming, internships, seminars, and case studies.

Four Pillars of Integrated Water Resources Management

Systems Analysis includes system evaluation, optimization approaches, statistical analysis, simulation modeling, decision analysis, risk assessment, multicriteria analysis, and the development of indicators and metrics for analyzing problems.

The Science and Technology of Water involves hydrology, fate and transport of environmental contaminants, water chemistry, water quality, water conservation, and water resources engineering.

Biological Aspects of Water, Health and Nutrition covers ecology, environmental impacts, food and nutrition, epidemiology of water-borne diseases and animal-to-human transmission through water, and ecohydrology.

Planning and Policy of Water includes environmental and water resource economics; legal and institutional frameworks; social, cultural, and behavioral issues; water security at the household, local, regional, national, and international levels; the ethics of local, national, and international systems for dealing with water security; and how to integrate them and other issues in the planning process.

Other components of a graduate program should include hands-on opportunities and exposure to the application of IWRM. These could be achieved through workshops, internships, and seminars related to IWRM. We also envision skills workshops covering topics including public speaking, teaching, development of research and program proposals, project management and budgeting, and the ethical conduct of research. Perhaps the most important aspect of the graduate program would be the requirement of an interdisciplinary thesis or research project where a student would conduct original research or a focused project effort as part of a larger research project involving multiple disciplines and their interactions. This experience would provide an opportunity for a student to practice integrating her/his skills into a larger project and contributing to problem resolution with other disciplines. U.S. and international perspectives should play a central role in any such program.

Challenges in Graduate Education in Integrated Water Resources Management

There are many challenges in academic institutions to implementing a cross-disciplinary graduate program in IWRM. The most notable is that universities are traditionally organized by discipline, and the goal of graduate education, particularly doctoral, is to become specialized in a single area. Tenure and promotion decisions are traditionally based upon recognized expertise in a narrow discipline. Some universities do have interdisciplinary water programs but they are usually limited to the melding of several scientific and/or technical specialty areas, such as hydrology and meteorology, or hydrology and ecology. Attempts to broaden the curriculum to social sciences often result in sets of electives that are unrelated with no or minimal overlapping themes, and perhaps only marginally linked to the broader issues of IWRM. School administrators are also at times focused upon the success of their own programs and not on larger cross-university initiatives.

Summary

It is now clear that ‘‘A holistic, systemic approach, relying on integrated water resource management must replace the fragmentation in managing water’’ (World Commission on Water 2000). To reach this goal, a new paradigm for interdisciplinary graduate education is needed. Given the pressing need for IWRM, graduate schools must start to rethink their approaches to training in water so that interdisciplinary and integrative skills are obtained in IWRM. Tufts University has accepted the challenge in its new graduate MS/MA and PhD program *Water: Systems, Science, and Society* (WSSS), where students receive in-depth training in any field related to water management but also become knowledgeable in the other disciplines and their approaches to water management. (See http://www.tufts.edu/water for further information.) We hope this will become a model of advanced education in IWRM.

References

Colwell, R. (2002). ‘‘A global thirst for safe water: The case of cholera.’’ *Abel Wolman Lecture*, National Academy of Sciences, Washington, D.C., January 24.

Intergovernmental panel on climate change, impacts, adaptation, and vulnerability (IPCC). (2001). Cambridge University Press, Cambridge, Mass.

Major, D.C. (1997). ‘‘Multiple objective water resource planning.’’ *Water Resources Monograph 4*, American Geophysical Union, Washington, D.C.

Ocean Conservancy. (2002). *Ocean Results Committee Report*, September 7, Washington, D.C.

Stakhiv, E. Z., (2003). ‘‘Disintegrated water resources management in the U.S.: Union of Sisyphus and Pandora.’’ *J. Water Resour. Plan. Manage.*, 129(3), 146–154.

United States Environmental Protection Agency (U.S. EPA). (1996a). *National water quality inventory*, Washington D.C.

United States Environmental Protection Agency (U.S. EPA). (1996b). *Clean water needs survey*, Washington D.C.

U.S. National Research Council. (2001). *Envisioning the agenda for water resources research in the twenty-first century*, Washington, D.C.

United Nations (UN). (1997). ‘‘Comprehensive assessment of the freshwater resources of the world.’’ *E/CN.17/197/9*, New York.

United Nations Educational, Scientific and Cultural Organization (UNESCO). (2003). ‘‘Water for people, water for life.’’ *United Nations World Water Development Rep.*, New York.

World Commission on Water. (2000). ‘‘A report of the World Commission on Water for the 21st century.’’ *Water Int.*, 25(2), 284–302.