WATER RESOURCES PLANNING

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1. Introduction

Over the centuries aquifers and rivers have been a source of water supply for agricultural, municipal, and industrial consumers. Rivers have provided hydroelectric energy an inexpensive means of transporting bulk cargo between different ports along their banks. They have provided people water-based recreational opportunities and have been a source of water for wildlife and their habitat. They have also served as a means of transporting and transforming waste products discharged into them. The quantity and quality regimes of streams and rivers have been a major factor in governing the type, health and bio-diversity of riparian and aquatic ecosystems. Floodplains have provided fertile lands for agricultural crop production and relatively flat lands for the siting of roads and railways and commercial and industrial complexes. In addition to the economic benefits that can be derived from rivers and their floodplains, the aesthetic beauty of most natural rivers has made lands adjacent to them attractive sites for residential and recreational development. Rivers and their floodplains have generated, and, if managed properly, can continue to generate, substantial economic, environmental and social benefits for their inhabitants.

Human activities undertaken to increase the benefits obtained from rivers and their floodplains may also increase the potential for costs and damages when the river is experiencing rare or extreme flow conditions, such as during periods of droughts, floods and heavy pollution. These costs and damages are economic, environmental and social. They result because of a mismatch between what humans expect or demand, and what nature offers or supplies. Human activities tend to be based on the 'usual or normal' range of river flow conditions. Rare or 'extreme' flow conditions outside these normal ranges will continue to occur, and possibly with increasing frequency as climate change experts suggest. River-dependent human activities that cannot adjust to these occasional extreme flow conditions will incur losses.

The planning of human activities involving rivers and their floodplains must consider certain hydrologic facts. One of these facts is that flows and storage volumes vary over space and time. They are also finite. There are limits to the amounts of water that can be withdrawn from surface and groundwater bodies. There are also limits to the amounts of potential pollutants that can be discharged into them. Once these limits are exceeded, the concentrations of pollutants in these waters may reduce or even eliminate the benefits that could be obtained from other users of the resource.

Water resources professionals have learned how to plan, design, build and operate structures that together with non-structural measures increase the benefits people can obtain from the water resources in rivers and their drainage basins. However, there is a limit to the services one can expect from these resources. Rivers under stress from over development and use cannot reliably meet the expectations of those depending on them. How can these renewable, yet finite resources best be managed and used? How can this be accomplished in an environment of uncertain supplies and uncertain and increasing demands, and consequently of increasing conflicts among individuals having different interests in the management of a river and its basin? The central purpose of water resources planning and management activities is to address, and if possible answer, these questions. These questions have scientific, technical, political (institutional) and social dimensions. Thus so must water resources planning processes and products.

River basin managers - those responsible for managing the water resources in a river - are expected to manage those resources effectively and efficiently, meeting the demands or expectations of all users, and reconciling divergent needs. This is no small task, especially as demands increase, as the variability of river flows becomes more pronounced, and as stakeholder measures of system performance increase in number and complexity. The focus or goal is no longer simply maximizing economic net benefits, and making sure the distribution of those benefits is equitable. There are also environmental and ecological goals to consider. Rarely are management questions one dimensional, such as how can we provide, at acceptable costs, more high-quality water to increase the irrigation area in the basin. Now added to that question is how those withdrawals would affect the downstream hydrologic water quantity and quality regimes, and in turn the riparian and aquatic ecosystems. To address such 'what if' questions, requires the integration of a variety of sciences and technologies with people and their institutions.

Problems and opportunities change over time. Just as demands on the management and use of water change over time, so do the processes of planning to meet these changing demands. Planning processes evolve not only to meet new demands and expectations and objectives, but also in response to new perceptions of how to plan more effectively.

This paper attempts to review some of the issues requiring water resources planning and management. Additional information is available in many of the references listed at the end of this chapter.

2. Planning and Management Issues: Some Case Studies

Managing water resources certainly requires knowledge of the relevant physical sciences and technology. But at least as important, if not more so, are the multiple institutional, social or political issues confronting water resources planers and managers. The following brief descriptions of some current international, national and local water resources planning and management studies illustrate some of these issues:

2.1 Kurds Seek Land, Turks Want Water

The Tigris and Euphrates Rivers (Figure 1) created the “Fertile Crescent” where some of the first civilizations emerged. Today they are immensely important resources, politically as well as geographically. In one of the world’s largest public works undertakings, Turkey is spending $32 billion for the huge Southeast Anatolia Project, a complex of 22 dams and 19 hydroelectric plants. Its centerpiece, the Ataturk Dam (Figure 2) on the Euphrates River, is already completed. In the lake formed behind the dam, sailing and swimming competitions are being held on a spot where for centuries there was little more than a desert (Figure 3).

Figure 1: The Tigris and Euphrates Rivers in Turkey, Northern Syria and Iraq

When the project is completed, perhaps in the next decade, it is expected to increase the amount of irrigated land in Turkey by 40 percent and provide one-fourth of the country's electric power needs. Planners hope this can improve the standard of living of six million of Turkey's poorest people, most of the Kurds, and thus undercut the appeal of revolutionary separatism. It will also deprive Syria and Iraq of resources those countries believe they need—resources that Turkey fears might ultimately be used in anti-Turkish causes.

Figure 2: Ataturk Dam on the Euphrates River in Turkey

Figure 3: Water sports on Ataturk Reservoir on the Euphrates River in Turkey

The region of Turkey where Kurd's predominate is more or less the same region covered by the Southeast Anatolia Project, encompassing an area about the size of Austria. Giving that region autonomy by placing it under Kurdish self-rule could weaken the central Government's control over the water resource that it recognizes as a keystone of its future power.

In other ways also, Turkish leaders are using their water as a tool of foreign as well as domestic policy. Among their most ambitious new projects is one to build a 50-mile undersea pipeline to carry water from Turkey to the parched Turkish enclave on northern Cyprus. The pipeline will carry more water than northern Cyprus can use. Foreign mediators, frustrated by their inability to break the political deadlock on Cyprus, are hoping that the excess water can be sold to the ethnic Greek republic on the southern part of the island as a way of promoting peace.

2.2 Sharing the Water of the Jordan River Basin

A growing population – now approximately 12 million people – and intense economic development in the Jordan River Basin (Figure 4) are placing heavy demands on its scarce freshwater resources. Though the largely arid region receives less than 250 millimeters of rainfall each year, total water use has been increasingly steadily to support agricultural and economic activities. Moreover, many important sources of high-quality water in the region are deteriorating with encroaching urban development and agricultural use.

The combined diversions by the riparian water users have changed the river in its lower course into little better than a sewage ditch. From the 1,300 million cubic meters (mcm) of water that used to flow into the Dead Sea in the 1950s only a small fraction remains at present. In normal years the flow downstream from Lake Tiberias (also called the Sea Of Galilee or Lake Kinneret) is some 60 mcm - about 10% of the natural discharge in this section. It basically consists of saline springs and sewage water. These flows are then joined by what is left of the Yarmouk, by some irrigation return flows, and by winter runoff, adding up to a total of from 200-300 mcm. Both in quantity and quality this water is unsuitable for irrigation and does not sufficiently supply natural systems either. The salinity of the Jordan River reaches up to 2,000 parts per million (ppm) in the lowest section, which makes it unfit for crop irrigation. Only in flood years is fresh water released into the lower Jordan Valley.

One result of this increased pressure on freshwater water resources is the deterioration of the region's wetlands, which are important for water purification and flood and erosion control. As agricultural activities expand, wetlands are being drained, and rivers, aquifers, lakes and streams are being polluted with runoff containing fertilizers and pesticides. Reversing these trends by preserving natural ecosystems is essential to the future availability of fresh water in the region.

To ensure that an adequate supply of fresh, high-quality water is available for future generations, Israel, Jordan, and the Palestinian Authority must work together to preserve aquatic ecosystems (White, et al. 1999). Without these natural ecosystems, it will be extremely difficult and expensive to sustain high-quality water supplies. The role of ecosystems in sustaining water supplies has largely been overlooked in the context of the region's water supplies. Vegetation controls storm water runoff and filters polluted water, and it reduces erosion and the amount of sediment that makes its way into water supplies. Streams assimilate wastewater, lakes store clean water, and surface waters provide habitat for many plants and animals.

The Jordan River Basin just like most river basins should be evaluated and managed as a whole, to permit the comprehensive assessment of the effects of water management options on wetlands, lakes, the lower river, and the Dead Sea coasts. Damage to ecosystems and loss of animal and plant species should be weighed against the potential benefits of developing land and creating new water resources. For example, large river-management projects that divert water to dry areas have promoted intensive year-round farming and urban development, but available river water is declining and becoming increasingly polluted. Attempting to meet current demands solely by withdrawing more ground and surface water could result in widespread environmental degradation and depletion of freshwater resources.

There are policies that if implemented could help preserve the capacity of the Jordan River to meet future demands. Most of the options relate to improving the efficiency of water use – that is, they involve conservation and better use of proven technologies. Also being considered are policies that emphasize economic efficiency and reduce overall water use send signals to consumers about the true cost of water. Charging higher rates for water use in peak periods, and surcharges for excessive use, would encourage conservation. In addition, new sources of fresh water can be obtained through using watershed management techniques and capturing rainfall through rooftop cisterns, catchment systems, and storage ponds.

Thus there are alternatives to a steady deterioration of the water resources of the Jordan Basin. They will require coordination and cooperation among all those living in the basin. Will this be possible?

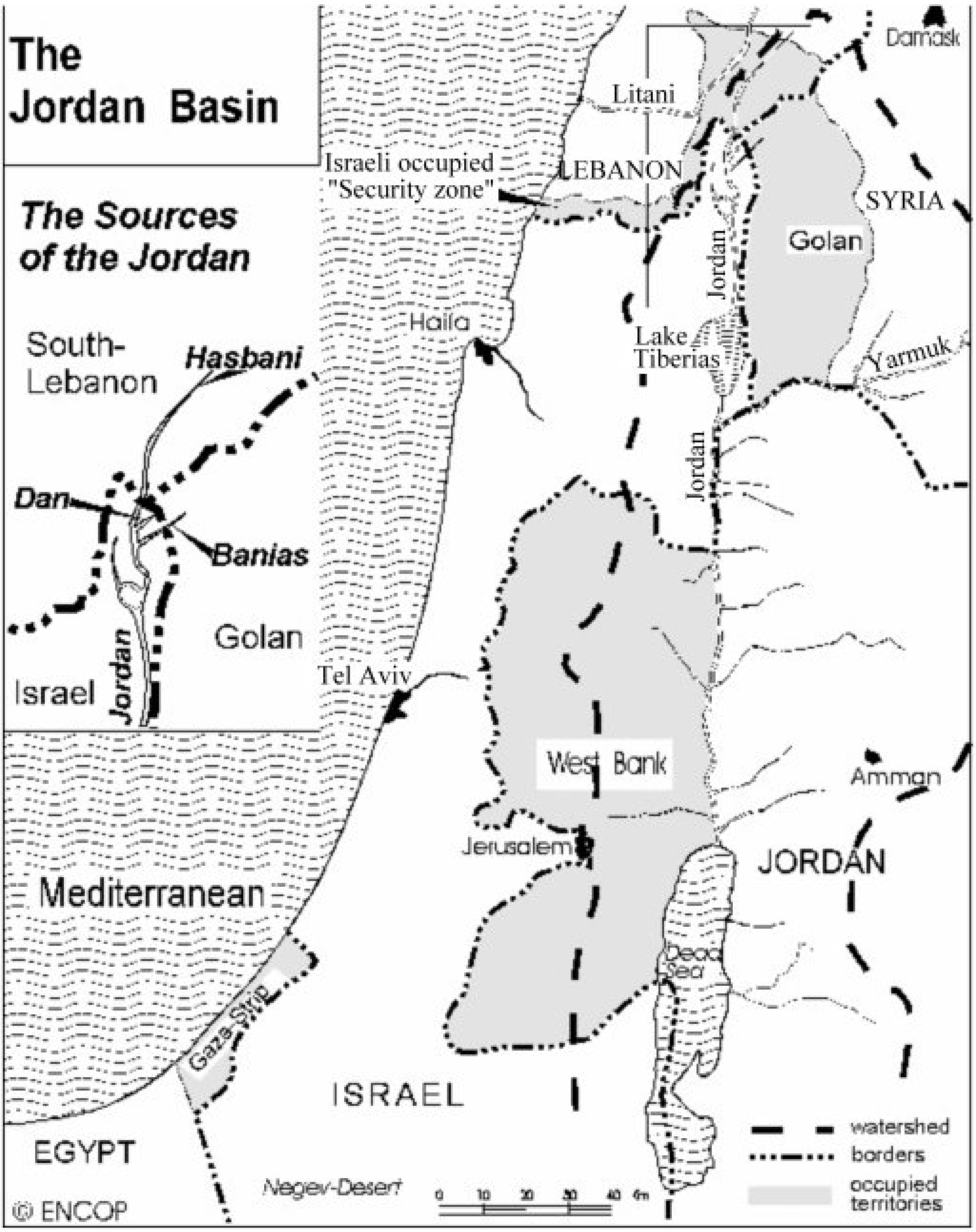

Figure 4: The Jordan River between Israel and Jordan

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Biographical Sketch

Professor Loucks teaches and carries out research in the application of systems analysis, economic theory, ecology and environmental engineering to problems in regional development and environmental quality management including air, land, and water resource systems. He has authored articles and book chapters in these subject areas. He served as Chair of the Department from 1974 to 1980, and as Associate Dean for Research and Graduate Studies in the College of Engineering from 1980 to 1981. He has also been a Research Fellow at Harvard University (1968); an Economist at the Development Research Center of the World Bank (1972-73); a Research Scholar at the International Institute for Applied Systems Analysis (1981-1982); and a Visiting Professor at the Massachusetts Institute of Technology (1977-78), the University of Colorado in Boulder (1992), the University of Adelaide in South Australia (1992), the Aachen University of Technology in Germany (1993 and 1995), the Technical University of Delft in the Netherlands (1995), and the University of Texas in Austin (2000). Since 1969 he has served as a consultant to private and government agencies and various organizations of the United Nations, the World Bank, and NATO involved in regional water resources development planning in Asia, Australia, Eastern and Western Europe, the Middle East, Africa, and Latin America. From 1975 to 1978 he was a consultant to the U.S. Environmental Protection Agency participating in the US-USSR exchange program on environmental protection. Since 1976 he has been a visiting professor in water resources-environmental systems engineering at the International Institute for Hydraulic and Environmental Engineering in Delft, The Netherlands.

Loucks has served on various committees of the National Research Council of the National Academy of Sciences, and was a U.S. member of an advisory committee for the International Institute for Applied Systems Analysis (IIASA) in Laxenburg, Austria. From 1977 to 1990, he served as a member of the IIASA liaison committee of the National Academy of Sciences, and of the American Academy of Arts and Sciences. The Secretary of the Army appointed him to US Army Corps of Engineers Environmental Advisory Board in 1994. He served as Vice Chair and Chair from 1995 to 1998, and received the Commander's Award for Public Service in 1998. He currently is a member of a NRC committee on the Restoration of the Greater Everglades Ecosystem and of an International Joint Commission Study Board pertaining to the Great Lakes.

Loucks was awarded the Huber Research Prize in 1970 and the Julian Hinds Award in 1986 by the American Society of Civil Engineers. He was elected to Fellow in the Society in 1983 and to Honorary member in 1998. In 1975 he received a Fulbright-Hayes Fellowship to lecture in Yugoslavia. He has chaired various committees in professional societies in civil engineering, geophysical science, and operations research. He is a member of five honorary societies, including Sigma Xi and Phi Kappa Phi, and serves as an associate editor and as a member of editorial boards of professional journals in the U.S. and in Europe. He was elected to the National Academy of Engineering in 1989. He received Distinguished Lecture Awards by the National Research Council of Taiwan in 1990 and 1999, an EDUCOM Award for software development in 1991, the Senior U.S. Scientist Research Award from the German Alexander von Humboldt Foundation in 1992, and the Warren A. Hall Medal from the Universities Council on Water Resources in 2000. . Loucks was commissioned in the U.S. Navy in 1955. He served as an aviator on active duty until 1959 and subsequently in the Naval Reserve until 1981. From

1979 to 1981 he commanded VR-52, the largest Naval Air Transport Squadron in the country having detachments at Naval Air Facility, Detroit, MI, Andrews Air Force Base, MD, and Naval Air Station, Willow Grove, PA. In 1981 he was awarded the Navy's Commendation Medal by the Secretary of the Navy. He retired as Captain from the Naval Reserve in 1992.