WATER RESOURCES IN THE MIDDLE EAST: AN AGENDA FOR REGIONAL COOPERATION

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INTRODUCTION

For thousands of years, land and water resources have been exploited in the Middle East and North Africa. Arable land and reliable water resources, however, have been exhausted, and the region subsequently faces two major challenges. First, high population growth is forcing expansion of cultivation onto marginal land and engulfing prime agricultural land and water resources to accommodate the region's accelerating urbanization. Second, the conflicting and competing demands for prime land and water discourage constructive investment and management of these important resources. As a result, major ecological and political problems confront the region, with the water crisis a prominent political issue, especially along the international river basins of the Tigris, Euphrates, Jordan, and Nile rivers. This paper focuses on the region's water resources, which are the most important factor limiting the growth of agriculture and influencing the management of irrigated lands.

BACKGROUND TO THE WATER CRISIS

A recent report on world resources identifies the Middle East as the main region where water shortages have reached crises proportions. Jordan, Israel, Algeria, Egypt, Tunisia, and the countries of the Arabian Peninsula are already reaching a point where nearly all available supplies are being used. Israel and Jordan, for example,have low levels of per capita water supply, 370 and 150 m^3 respectively, compared with Cyprus (1,280m^3) and the U.S. (1,940m^3). Israel the West Bank and Gaza, and Jordan are facing a combined water deficit of at least 300 million m^3 per year. The region's water crisis is aggravated because many countries share common water resources, yet have no common agreements on how to efficiently and productively share them. There is also a lack of cooperation in the sharing and management of the region's ground-water resources; for example, the Yarqon-Tanninim aquifer, which provides 25 to 40 percent of Israel's water, lies beneath pre-1967 Israel and the West Bank. Its management, recharge, protection from

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pollution, and efficient utilization should receive higher priority than its political disposition because of the long-term implications for the sustainability of the aquifer. Also, the development of the Jordan and Yarmouk river basins has lagged because of the political conflict in the region. An agreement to develop these basins could provide substantial incentives to all parties to realize the multipurpose benefits of such cooperation to the region's economic growth, environmental protection, and infrastructural development. Moreover, because of the scarcity of water, major structural changes are likely to be introduced in agriculture, industry, and urban planning. The countries of the region do not have much room to maneuver and their options are limited. Cooperation is thus imperative.

TRADITIONAL WATER USE

The main water user in the region is irrigation. Total irrigated land is less than 10 percent of all arable land yet consumes about 70 percent of all water resources in the region. Originally the main irrigation schemes in the region were constructed to provide additional food supplies, mainly wheat (except in Sudan, where irrigation works were built to grow cotton). As commodity prices declined in the 1980s, and returns to irrigation projects diminished, farmers shifted to growing vegetables, fruits, cotton, and oilseeds. Governments have been reluctant to support this shift on the grounds that such changes may endanger national food security. Government interventions to increase food production on irrigated lands have sometimes led to a deterioration of the sector because of low returns and discriminatory pricing policies. This is evident in the management of irrigated land, where field efficiency in the traditional sector (gravity irrigation for staple food crops) is low and cropping intensity of irrigated areas averages 140 percent (subject to availability of water), compared with 240 percent in East Asia. Although water is scarce and expensive, low-value crops and water-demanding production systems have been encouraged because of poor water policies and heavy government interventions to establish cropping patterns, crop quotas, and pricing policies for crops grown under irrigation. Three countries, Egypt, Jordan, and Israel, provide vivid examples of the severity of water shortages and the agricultural sector's response to this crisis. Jordan, which receives an average of 250 to 325 mm of rainfall annually, consumes 110 percent of its water stock annually and has accumulated a deficit equal to one full year's supply (caused by the overpumping of the shallow aquifer). Egypt, which is completely dependent on the flow of the Nile River, experienced major crises during the droughts of the 1980s, and its program to expand agricultural land on both sides of the Nile Delta is being threatened by water shortages. The new land development program is now designed to recycle irrigation water, which is likely to

be more saline and of poor quality, possibly threatening the long-term sustainability of the newly reclaimed lands. In Israel, where the contribution of agriculture to the national economy is declining, modern irrigation systems have become the main investment to commercialize the sec

POLICIES AND GOVERNMENT ACTIONS

These three countries are approaching the situation with different methods, but they subscribe to the same strategy of addressing the allocation of water to agriculture and overall national water policies. Because irrigation is the main user of water, issues affecting it receive attention, especially those related to crop production, efficiency, modernization of systems, pricing and allocation of water, and protection of the environment from the serious consequences of the continual intervention in hydrological cycles. The results of government intervention in any of these areas are not always consistent because of the region's diverse water use. Irrigation systems vary from traditional farmer-built spate irrigation schemes in upper Egypt, to modern drip irrigation systems used in greenhouses for fruits and vegetables in Israel, Jordan, and lower Egypt. Water projects also range from earth dams in eastern Jordan to large, sophisticated, and multipurpose dams in Egypt and Jordan, and to a national reservoir and carefully programmed water carrier in Israel

In some aspects, the region has had great success in water management, and it has supported the adoption of modern technology in canal conveyance systems and on-farm water distribution. Nevertheless, the problem is intensifying. The growing scarcity of water resources in the region is caused by three major factors: rapid population growth, deteriorating water quality, and the rising cost of new water projects. Again, Egypt, and Jordan, and Israel illustrate how countries have been trying to deal with this situation.

Egypt

Egypt relies on the Nile River for 95 percent of its water consumption. Egyptian water management, dominated by agricultural consumption, is characterized by a rigid water distribution system, extending 1,000 km, and by the continuous threat of salt-water intrusion into the Nile Delta. Over 95 percent of agricultural production is derived from irrigated land. Egypt's population grows at an average of 2.7 percent, with about one million people every ten months. The area of arable land per capita is dismally low; by 1991 there were 24 people to every hectare of

arable land. Attempts to expand agricultural land have been difficult and expensive. Of the 7.5 million acres of cultivated land in Egypt, about 800,000 acres were reclaimed on both sides of the Nile Delta in the last 40 years. There are plans to add about 2.5 million acres of new lands, but water scarcity is challenging this endeavor.

During the 1980s, in an effort to increase water and land use efficiency, the government launched a major policy shift regarding land use. The government realized that the overall performance of state farms was inefficient, unable to adopt quickly new farming practices that could adjust to arid and desert conditions. This shift was also necessary because the new lands are likely to consume 10 percent of total water available in the country. Efficient utilization of this scarce commodity requires the establishment of responsive systems in land property rights, water use and management, and adoption of modern production technology.

The challenge to bringing about the needed changes is that traditional, centuries-old surface irrigation systems are used in most cultivated land of the Nile Valley and Delta. Because of the low efficiency of water use in the Nile Valley, the government dictated that the new lands be irrigated with modern systems such as drip or sprinkler systems. Although modern irrigation has allowed the new lands to improve agricultural production and shifted cropping patterns toward high-value crops, including fruits, vegetables and oilseed, the pressure continues to change traditional cropping patterns in irrigation systems in the Nile Valley that cause large losses in water; for example, about 25 to 30 percent of irrigation water supply is allocated to rice and sugarcane. These crops seem profitable from the farmer's perspective but are expensive from a social perspective, in view of the free water supplied to the farmers while their counterparts in the new lands pay substantial sums for investment and delivery of water. The disparity of the situation is more serious in certain parts of the delta where farmers can only use recycled drainage water for their irrigation. Under these conditions, farmers receive low-quality water loaded with salts and chemicals that is likely to cause long-term damage to the soil and groundwater. A recent study of water resources in Egypt concluded that the present land use and water delivery systems face the following constraints:

- Fragmented lands and small holdings have constrained the establishment of efficient irrigation methods.

- The present water rotation system is unsuitable for using modern technologies, such as sprinkler or drip irrigation, which usually require a continuous supply of water.

- Accurate water control under the present irrigation regime is difficult, especially with different water demands regarding frequency and quantity for different crops.

The study proposed several steps to address this situation, including:

- improving the efficiency of the present irrigation system in old lands and developing modern irrigation methods in new lands that would allow planning a reliable irrigation schedule for different crops;

- improving drainage networks and reducing losses;

- recovering the cost of irrigation development and operation from farmers.

Because water is the major constraint to further expansion of agricultural areas, treated wastewater must be considered as a new source of irrigation water. Urgent steps should be taken to establish pilot projects on the use of treated wastewater in agriculture.

Agricultural drainage water in upper Egypt is discharged back into the Nile River. This affects water salinity. Strict policies have been imposed regarding the release of Nile water downstream of the Aswan High Dam. A potential decrease in drainage water quantity and an increase in its salinity will occur when irrigation efficiency is improved both in the conveying system and at the farm level. Currently, however, the increasing release of drainage water for irrigation may pose a considerable environmental challenge because of the strong likelihood of creating serious salinity problems in the delta.

The problems that are likely to challenge the sustainability of water resources in Egypt include salinity, waterlogging, the declining quality of fresh water, and water pollution as a result of continuous discharge into the Nile and wastewater from domestic and industrial use, usually untreated in irrigation canals. Also likely to aggravate the pollution problems is the increased use of chemicals, especially nitrogen, phosphate, and potash, which has increased fourfold in the last

three decades. The use of herbicides, especially acrolein to control submerged weeds in canals and ametryn to control water hyacinths in drains, has caused serious environmental hazards and is likely to be discontinued. Ironically, new technologies introduced to improve operation and maintenance may have adverse environmental impacts and challenge the sustainability of the system.

Jordan

Jordan's water resources situation is somewhat different. Jordan has an arid climate, and only 5 percent of the land area receives sufficient rainfall to support cultivated agriculture. Less than 10% of the agricultural land is irrigated but accounts for about 20 percent of the value of exports. The surface water resources in Jordan, especially in the Jordan Valley, have been extensively developed despite high investment costs. Irrigation in the Jordan Valley consumes about 65 percent of the country's total utilizable surface water. Irrigation efficiency varies from 70 percent for the lands irrigated through direct pressure pipes to 38 percent for surface irrigation. The severe water shortage in the valley restricts cropping intensity to 115 percent (one of the lowest ratios of intensification of irrigated lands worldwide). An increasing proportion of the irrigation water currently used consists of return sewage flows. About 35 percent of total irrigation water is likely to be from sewage flows in the next two decades. Because of the severe shortage of water, the government has taken the following actions:

- converting irrigation systems in the Jordan Valley from surface to pressure pipe systems;
- introducing automated water management control systems at the farm level;
- imposing area restrictions on low-value and high-water-consuming crops;
- encouraging cultivation of high-value, import substitute crops;
- selling a fixed volume of water to farmers, determined annually according to water availability;

- strengthening research and extension on alternative crops, especially those with relatively low water requirements;

- designing a practical and objective allocation system, using long-run management and cost pricing of water to help guide the allocation of water to irrigation against competing demands, and, within agriculture, to help determine optimal cropping patterns.

Israel

In Israel, the government has initiated several innovations designed to deal with the problems of water scarcity, allocation, and economic growth. The construction of the Israeli National Water Carrier is a centralized engineering and management project which channels water from Lake Kinneret/Sea of Galilee in the north to the coastal regions and into the south. The carrier has evolved from a water transfer project to a large-scale centralized distribution network, comparable to a system serving a large urban-industrial complex. The various sources of water available to Israel, both surface and groundwater, are brought into the water carrier and distributed to the various regions, to cities and towns, and to the irrigation districts. An additional source in recent years is the pipeline which carries reclaimed wastewater from Tel Aviv to irrigate several thousand hectares in the south. This project allowed the water carrier to diversify its services beyond conveying fresh drinking water to include different quality water for different users in agriculture and industry, managed and controlled by sophisticated monitoring and distribution systems.

Along with these modifications, Israel has been transforming the structure of its agriculture to be responsive to scarce and expensive water resources. High-value crops and industrialized cropping systems have been replacing traditional agriculture and are based on highly automated irrigation systems, including drip and sprinklers operated through computerized water demand and assessment centers with remote water screening and computerized command program for efficient response to crop water requirements. Such systems allowed Israeli farmers to use water efficiently, diversify into crops with fewer water requirements, and introduce the high technology needed to transform agriculture into viable commercial enterprises.

Changing the agricultural system in Israel has been made possible through heavy investment in the development and improvement of irrigation technology. Over the years, Israel has supported the establishment of several factories to produce advanced models for drip, sprinkler, fertigation, and multiple irrigation systems for controlled and highly managed cropping systems (flowers, fruits, vegetables, and industrial crops). These innovations have allowed Israel to temporarily address the growing problems in the water sector, including scarcity and allocation among competing sectors, declining quality, and increasing environmental concern about excessive water use.

A CASE FOR REGIONAL COOPERATION

Despite some country success in managing water resources, the future challenges in meeting the growing demands for water are beyond the capabilities of individual countries. Water does not respect national boundaries; even underground aquifers cut across national boundaries. Regional rainfall, river water, lakes, and groundwater are all part of one system. The region faces drought every four years, and no national boundaries protect against floods or droughts. As the economic growth process continues in the region, and the expansion of economic activities inevitably leads to increasing demands for water, the answer to these challenges cannot be found within one country's national boundary. Joint action to prepare a regional response to the future challenges may encourage the countries of the region to recognize that regional water management could be employed to enhance peace rather than fuel conflict. Countries should focus on sustainable management of their water resources, which are international in nature, addressing the serious environmental consequences of water resources development, which require immediate regional cooperation. This involves water planning based on hydrological units, such as an entire drainage basin. A concerted regional effort should focus in particular on the areas discussed below.

Exchange of Information and Data on the Water Sector

The countries in the region need to establish a regional information and data base for hydrometeorology and water use. An integrated regional information system is needed to regularly record and disseminate climatic data, including rainfall and data from hydrology networks and river-gauging stations. The system should also include data on groundwater and land use planning. Experience elsewhere in the world suggests that the countries in the region would

benefit from establishing an institutional framework for conventional - and remote-sensing data programs. This framework should set data collection standards, monitor and integrate water data from all sources, and submit regular and intermittent data compilation reports and studies. The regional systems should be responsible for the collection of data of national and international interest, and make information available equally to all concerned government agencies in the region. The recent advances in the Geographic Information System (GIS) can make this proposition equally attractive to the countries of the region. A concerted effort is needed to strengthen the national hydrological institutions in the region and to assist them in establishing a regional information, training, and dissimination center.

Regional Management

The establishment of a regional data and information base should be targeted toward better management of water resources. The vehicle toward this goal is integrated river basin planning which recognizes the dynamics of the river. At headwaters we need to plan to protect the hills and watersheds. In the middle sections, where land is flat and the flow is slow, we need to plan for efficiency and protection from highland evaporation and losses, and the lowlands, where groundwater is usually recharged and wetland and lakes could formulate natural drainage and storage systems, we need to develop a system which could stabilize the salt balance in the region.

Effective water management of the Jordan River, for example, requires a broad plan for the entire river basin. This is particularly challenging because the river is under the jurisdiction of four nations. Existing international law offers little guidance in international river basin planning and provides no help in areas where political and military conflicts have been dominant features along these basins. Regional cooperation in establishing innovative legal, institutional, and organizational structures responsive to the region's water situation is urgently needed to address efficient water management, reduce pollutants in river basins, establish environmental standards for wastewater treatment and recycling, and monitor water on a seasonal basis to adjust allocations among competing sectors with limited disruption to the economic activities of the communities dependent on a river basin.

Successful river basin planning is found in the Pacific Northwest of the United States, where a regional water management and conservation system along the Columbia River has been in effect for several decades. This approach is carried out according to a sophisticated supply

management system through automated sensing and transmission of water resource data in real time from unattended remote sites to computerized base stations where it can be easily accessed and analyzed by water resource managers. The supply management is supported by conservation management through a variety of networks of automated agricultural weather stations dedicated to crop water use modeling and conservation programs aimed at providing direct and indirect benefits to the energy resource mix in the region.

This approach has been complemented by water bank programs, which have proven to be a viable technique for managing existing supplies, providingwater for new users, and storing water for drought years. Under these arrangements water reservoirs are converted to function as water banks, and reservoir space is allocated to the different contracting entities and is based on criteria developed by water experts from the participating states.

This concept which has also been well received in California, is timely and relevant to the Middle East. The countries involved could become spaceholders in the reservoirs with technical and legal contracts for water rights. With spaceholder contracts, reservoir storage is attributed to the specific spaceholders. In years of normal or surplus water supply, unneeded water simply remains in the reservoir under the control of the spaceholder. Surplus water can be marketed to other users provided there is an assurance that the existing contractors will not suffer shortages as a result of the new use. The commitments to the original users will always be honored.

Converting existing reservoirs in the region into water banks requires an agreed upon legal framework, organizational structure, and management program accepted by the participating countries in the region. Water and legal experts, hydrologists, and political and economic advisors must be allowed to conduct necessary studies designed to assess the suitability of such innovative schemes in water banking and management as incentives toward a peaceful solution to the water problems in the region.

Modern Water Technology and Engineering

A third area of cooperation among the countries in the region is the development and improvement of modern water technology. Areas with water shortages are turning increasingly to desalination plants to supplement water resources. Globally, there are about 8,000 of these plants each producing over 100 m^3 per day, in about 120 countries. Saudi Arabia is the world leader in

desalination and produces about 27 percent of the estimated 14 million m^3 of global capacity. Desalination is still three to four times more expensive than conventional sources of fresh water, costing 40 to 60 cents per cubic meter of brackish water and US$1.05 to US$1.60 per cubic meter of sea water. Research and development of less costly technology for the region should be a high priority. Saudi Arabia and Kuwait, which jointly hold about 40 percent of global capacity of desalination plants, can benefit from supporting regional research efforts in this field. Other areas of technological innovation are new instruments, engineering designs, and hydrological tools needed for recharging groundwater and fresh water aquifers, and for controlling pollution along river basins and associated groundwater systems. The region should focus on modern technology for artificial recharge, earth dams, and watershed management and improving the micro-water catchments in the hills where water runoff and erosion can contribute to heavy water and soil losses. Associated with this technology is large-scale afforestation in the marginal and semiarid zones and fuller use and planning of the region's prime agricultural land.

The countries of the region have given increasing attention to the possibility of intrabasin water transfers (The Red Sea hydrological connection with the Dead Sea is good enough). Regional studies on the scope, cost, and consequences of such enterprises would be useful. We need to learn more about the feasibility and advantages of such options. We also need to study the dynamics of this transfer in terms of hydrology, engineering, economics, and environmental dimensions. Before considering large water transfer projects, the region needs to assess its present distribution network, its capacity for connections with other networks within and outside the region, and methods of protecting water quality and quantity for future generations. Despite the severe water crisis in the region, few or no joint scientific studies have been designed for the sustainable development of this precious resource. The answer to the water crisis should not be a quick fix through water transfer. The initial phase of an action plan should emphasize a joint institutional approach to sustainable management based on sharing information, exchanging experience, and designing viable options to benefit the the countries sharing water resources.

CONCLUSION

The solution of the water crisis in the Middle East is beyond the capabilities of individual countries. Several countries in the region have successfully introduced innovative management technology designed to rationalize the development and improvement of water resources. The country experience has demonstrated that water management is a complex and expensive task. The

interdependence of water use, and the absence of regional cooperation makes a comprehensive approach to regional water resource management necessary. This approach requires concerted effort among the countries of the region to establish regional modern water information and hydrological data systems, regional management and water banks, and innovative engineering and hydrological projects for interbasin transfer.