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WATER RESOURCES: SECURITY IMPACTS IN THE JORDAN RIVER BASIN

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Major Max E. Kirschbaum

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Preface

Water sustains life, yet rarely is it a source of violent conflict in western societies. In parts of the Middle East, where water scarcity impacts everyday life, water issues are inseparable from politics and conflict. Water plays a key role in shaping the strategic environment of three Middle East river basins: the Tigris-Euphrates, the Nile, and the Jordan. I chose to examine the Jordan River basin for three basic reasons: relations between the five nations in the basin affect regional and international relations and US interests; the water supply and demand imbalance is greatest; and more than 20 attempts to resolve water issues this century have been unsuccessful. Water resources experts could solve current and projected water problems in theory, but in reality water remains entangled in Arab-Israeli peace talks.

I would like to thank Mr. Ron Burger from the Defense Intelligence Agency (DIA) for his oversight in shaping this research project. Mr. Burger requested this project to support ongoing research efforts within the Director of Central Intelligence Scientific and Technical Intelligence Committee’s Environmental and Life Sciences Working Group. I also would like to thank Major Warren J. “John” McChesney Jr., my faculty research advisor, for his guidance and assistance throughout the project. Finally, I would like to thank Ms. Janet Seymour, Air University librarian, for preparing a detailed bibliography tailored to my research needs.

Abstract

Many regional experts regard the Jordan River basin as the most likely flashpoint for conflict in the Middle East. Water is entangled in basin tensions because it has become the most precious resource. The 360-kilometer transnational Jordan River, its tributaries, and a handful of aquifers are the only sources of fresh water to sustain life, agriculture, and industry. Today, politicians and water experts alike recognize the strategic importance of water as a limited resource. Israel, the Occupied Territories, and Jordan fully use or exceed their renewable annual water supplies. The water problem will grow even more severe over the next decade as governments deal with Palestinian autonomy, Jewish immigration, and refugee resettlement issues.

This paper examines how water impacts security in the Jordan River basin and the extent technology can help solve the problem. The findings and conclusions are based on a literature review of materials published primarily since 1993.

The obstacles to solving the water crisis are significant but not insurmountable. History, management by state boundaries, international law, Islamism and Zionism, and agricultural self-sufficiency have effectively blocked mutually beneficial water development schemes. Solutions must be framed in the context of these obstacles. This paper concludes that desalination, wastewater reclamation, and interbasin transfers are three of the most promising supply-side technological solutions.

Chapter 1

Introduction

> *The one certainty in the Middle East today is that water has become a commodity as important as oil; to those who possess it, it is a means of leverage and a way of projecting power; to those who lack adequate supplies, a prime concern of national security must be to increase what is available. Those two concerns must often conflict.*
>
> —John Bulloch and Adel Darwish
> *Water Wars: Coming Conflicts in the Middle East*

Fresh water resources have been intertwined with politics and conflict in the Jordan River basin throughout this century. Conflict over water access and control increases in the basin as water availability and quality problems become more acute. This paper focuses on how water resources impact security in the Jordan River basin and the extent technology can solve the problem.

Background and Significance

Water is the most precious resource in Israel and the Occupied Territories, Jordan, Syria, and Lebanon. The 360-kilometer transnational Jordan River, its tributaries, and a handful of aquifers are the only sources of fresh water to sustain life, agriculture, and industry in this volatile region of the world. The Israelis, Jordanians, Syrians, Lebanese, and Palestinians have constantly disputed riparian rights to the Jordan River, and state boundaries have changed due, in part, to access to water. Today, politicians and water experts alike recognize the strategic importance of water as a limited resource. Water demand in Israel, the Occupied Territories, and Jordan exceeds renewable annual water supplies. The water problem will grow even more severe over the next decade as governments deal with Palestinian autonomy, Jewish immigration, and refugee resettlement issues. The question is whether water will be a source of continued conflict or cooperation. Peter Gleick, Director of the Global Environment Program at the Pacific Institute for Studies in Development, Environment, and Security, predicts political conflict remains more likely than military conflict.[1] He says that when water is finite, poorly distributed, and subject to control by a single nation, the temptation to use water for political purposes is irresistible.[2] Other regional experts and politicians regard the Jordan River basin as the most likely flashpoint for violent conflict in the Middle East. Former United Nations Secretary General Boutros Boutros-Ghali warned that the next war in the Middle East will be over water.[3]

Study Limitations

This paper is bounded by two uncontrollable conditions. The overriding condition is the difficulty of isolating the role of water in security issues. Water resources in the basin are embedded in culture, religion, political ideology, and economics. The second condition is hydrologic data variance in the literature. Chief among the reasons for the variance are a lack of data sharing among states, difficulty in estimating groundwater supplies, and some basin states treating consumption data as classified information.

Three simplifications help limit the scope of this paper without altering the complexity of the issue. First, historical conflict involving water is only traced back to 1947, the year before Israel became a state. Second, state boundaries are considered as they have existed since the Six Days War in 1967. State boundaries have been fluid throughout history and remain subject to change even today as the Arabs and Israelis deal with Palestinian autonomy. Third, only technological solutions to the problem are examined. Such simplification does not discount the viability of stand-alone economic and demand management models.

Preview of the Argument

Understanding the Jordan River basin and its history is fundamental to examining the security impacts of water resources. Chapter 2 outlines the basin's hydrologic components, supply, and demand. Chapter 3 examines the history of water-related conflict since 1947 and possible future flashpoints. Chapter 4 assesses security impacts and identifies several obstacles to resolving water quality and quantity problems. These obstacles lay a foundation for discussing some of the more promising technological solutions in Chapter 5.

Cooperation is possible over water resources in the Jordan River basin amid the swirl of political and violent conflict in the region, and technology can aid in solving the problem. As Dr. Elisha Kally, former head of the long-range planning group of TAHAL, the Israeli water planning agency, points out, the basin nations "…cannot afford wasting another sixty years in non-cooperation in the development and distribution of water resources."[4]

Notes

[1] Peter H. Gleick, "Water and Conflict: Fresh Water Resources and International Security," International Security 18, no. 1 (Summer 1993): 112.

[2] Jad Isaac and Hillel Shuval, ed., Water and Peace in the Middle East (Amsterdam: Elsivier Science B.V., 1994), 44.

[3] John Bulloch and Adel Darwish, Water Wars: Coming Conflicts in the Middle East (London: Victor Gollancz, 1993), 22.

[4] Elisha Kally, Water and Peace: Water Resources and the Arab-Israeli Peace Process (Westport, CT: Praeger Publishers, 1993), 23-24.

Chapter 2

Jordan River Basin Water Resources

> *All of the countries and territories in and around the Jordan River watershed-Israel, Syria, Jordan, the West Bank, and Gaza-are currently using between 95 per cent and more than 100 percent of their annual renewable freshwater supply.*
>
> —Aaron T. Wolf
> *Hydropolitics Along the Jordan River*

Understanding how political boundaries overlay Jordan River basin hydrologic features is essential to understanding the nature of water resources conflict. This chapter lays out the basin characteristics, describe the Jordan River basin water supply, and discuss current and projected water demands for each state and the Occupied Territories.

Basin Characteristics

Estimates of the total area of the Jordan River basin range from 16,335 km^2 to 18,300 km^2. The basin is considered semi-arid in the north and arid in the south. The Jordan River, the defining component of the basin, is 360 km long. Its total annual flow of 1,477 million cubic meters per year (MCM/yr), is, by comparison, only two percent of the Nile's total annual flow.

States and Nations

The Jordan River basin cuts through four states: Israel, Jordan, Syria, and Lebanon. Two of the Occupied Territories, the Golan Heights and the West Bank, are within the Jordan River basin. Gaza is not within the basin; however, this paper considers Gaza in the basin water balance due to its geographic proximity to the basin and its political connection to Israel. The map at Figure 1 shows that state boundaries do not conform to the basin perimeter. The basin includes five nations of peoples: Israelis, Jordanians, Syrians, Lebanese, and Palestinians. Riparian status changes over the length of the Jordan River.

Hydrologic Components

The Jordan River basin includes rivers and wadis (seasonal streams), fresh and saline surface storage, and aquifers. This paper is concerned primarily with renewable water resources. Deep, non-renewable aquifers are not included in this paper, unless specifically stated, because they may take thousands of years to recharge. Each component in the water system has its own hydropolitical issues.

Surface water. Three springs flow together to form the upper Jordan River. The Hasbani rises in Lebanon, the Banias rises in the Golan Heights, and the Dan rises in Israel. The upper Jordan River flows south to the basin's only natural freshwater surface storage, the Sea of Galilee (210 meters below sea level), otherwise known as Lake Tiberias or Lake Kinneret. Lebanon, Syria, the Golan Heights, and Israel are riparian to the upper Jordan and its headwaters. The lower Jordan River flows from the south end of the Sea of Galilee to its termination in the Dead Sea (saline, 400 meters below sea level).

Figure 1. Jordan River Basin Map

The Yarmuk River, which rises in Syria, and the Zarqa River, which rises in Jordan, flow into the lower Jordan River along with other, lesser streams. The Yarmuk and its tributaries have more than 20 dams. Syria, Israel, Jordan, and the West Bank are riparian to the lower Jordan.

Israel's National Water Carrier moves water from the Sea of Galilee south along the coastal plain and into the Negev Desert. Jordan's East Ghor Canal moves water from the southern end of the Yarmuk River south along the Israel-Jordan border.

Groundwater. Three aquifers lay beneath Israel and the Occupied Territories: Mountain, Coastal, and Gaza (Figure 2). The Mountain Aquifer is made up of three basins. The north-eastern basin recharges in the West Bank and discharges in Israel's Bet She'an and Jezreel Valleys. The western basin also recharges in the West Bank and discharges toward the Mediterranean coast of Israel. The eastern basin has five separate catchment areas in the West Bank that flow east to the Jordan Valley. The Coastal and Gaza Aquifers are connected along the Mediterranean coast. They are located outside the Jordan River basin, but they are essential sources of supply for Israel and Gaza. Twelve other aquifers lay beneath Jordan in the Zarqa, Yarmuk, and Jordan River basins.

Water Supply

Low precipitation, transboundary sources, pollution, salinity, and expanding populations all impact Jordan River basin water supplies.[1] The basin can supply an average 280 cubic meters per person per year (m^3/pn/yr), 220 m^3/pn/yr less than what

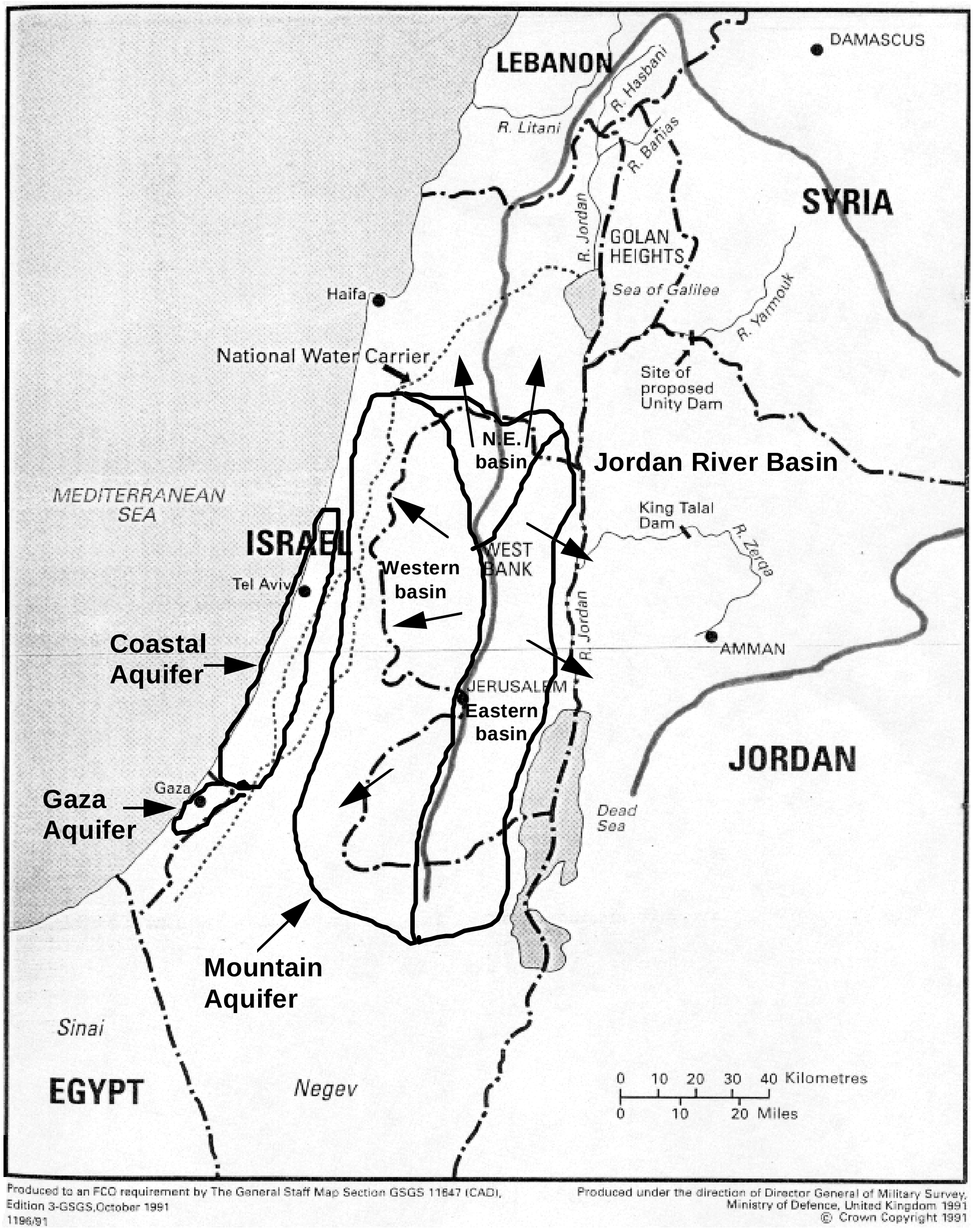

Figure 2. Jordan River Basin Area Aquifers Map

Swedish hydrologist Malin Falkenmark labeled the minimum “water barrier.”[2] It is useful to first examine the total renewable water supply balance of the Jordan River basin without regard to political boundaries and controls.

Surface Water

Table 1 shows the estimated natural annual flow of the Jordan River is 1,477 MCM/yr. This figure does not account for withdrawals through Israel’s National Water Carrier and Jordan’s East Ghor Canal. Water in the Jordan River becomes increasingly saline, and therefore less useful without treatment, as it progresses from the headwater springs to the Dead Sea. The Dead Sea is seven times more saline than the ocean.[3]

Table 1. Jordan River Basin Surface Water Balance

	Estimated Flow (MCM/yr)
Upper Jordan System	
Hasbani River (Lebanon)	125
Dan Spring (Israel)	250
Banias River (Golan Heights)	125
Local run-off (upper valley)	140
Sea of Galilee	
Spring flow (salty)	65
Precipitation	65
Local run-off	70
Evaporation	-270
Subtotal to Lower Jordan	570
Lower Jordan System	
Yarmuk River	400
Lower Jordan spring flow	185
Zarqa River and wadis	322
Subtotal in Lower Jordan	907
Total	1,477

Source: Wolf (1995)

Groundwater

Table 2 shows an estimated annual safe yield of 1,195 MCM/yr from the aquifers within, or proximate to, the Jordan River basin. Note that the safe yield reflects the recharge rate of the aquifer, but estimating the recharge rate and flow of an aquifer is subject to significant error.

Table 2. Jordan River Basin Area Aquifers Water Balance

	Safe Yield (MCM/yr)
Mountain Aquifer	
North-eastern basin	140
Western basin	320
Eastern basin	125
Coastal (not in Jordan River basin)	280
Gaza (not in Jordan River basin)	60
12 aquifers in Jordan (mostly in Jordan, Yarmuk, and Zarqa basins)	270
Total	1,195

Sources: Wolf (1995); Lowi (1993)

Current and Projected Demand

Examining total current and projected water demand data by state begins to illustrate the political reality of controlling a scarce resource. The impact of agriculture and population growth on water resources are serious throughout the Middle East; they are especially critical for most of the Jordan River riparians. Table 3 summarizes current and projected demand for the year 2000 by state; note that agriculture accounts for 73 to 85 percent of total water demand.

Table 3. Current and Projected Water Demand

	Current Demand (MCM/yr)	Renewable Supply (MCM/yr)[a]	Percentage to Agr/Dom/Ind[b]	Year 2000 Demand (MCM/yr)
Israel	1,900	1,600	73/22/5	1,940
Jordan	900	870	85/10/5	1,120
West Bank	125	125	78/22/0	159[c]
Gaza	95	60	85/15/0	200
Syria	6,700	27,000	not available	8,500
Lebanon	1,300	5,000	not available	1,448

Sources: Wolf (1995); Kliot (1994); Lowi (1993); Lindholm (1995)
a. Renewable supplies from all sources; not just the Jordan River basin.
b. Water allocation percentage for agriculture/domestic use/industry.
c. Agriculture consumption held constant under current policies.

Higher than average annual population growth rates account for a significant portion of the projected water demands. Table 4 shows that populations of Jordan, Syria, Gaza, and the West Bank will double or triple by the year 2020.

Table 4. Current and Projected Population

	1991 Population	Annual Growth Rate (%)	Projected 2020 Population[a]
Israel	4.80 million	1.6	8.85 million
Jordan	3.60 million	3.5	9.76 million
West Bank	0.90 million	3.4	2.37 million
Gaza	0.60 million	3.4	1.58 million
Syria	12.64 million	3.8	37.28 million
Lebanon	2.70 million	2.1	4.93 million
Total	25.54 million		64.77 million

Sources: Wolf (1995); UN, World Population Prospects 1990
a. Excludes projected immigration and refugee increases in Israel, Jordan, and the West Bank.

Israel

Israel's current water demand is 1,900 MCM/yr from sources entirely within the Jordan River basin. This total includes an estimated 500 MCM/yr withdrawn through the

National Water Carrier. It is important to be aware that 40 percent of Israel's sustainable groundwater supply (25 percent of total supply) originates in the West Bank.[4]

Nurit Kliot, Professor of Geography at the University of Haifa, Israel, states that TAHAL, the Israeli water planning authority, planned a water economy based on a supply of 2,000 MCM/yr.[5] Israel's current demand exceeds its available renewable resources by as much as 15 percent. The deficit is met through wastewater reclamation and desalination. Prior to 1991, the deficit was met through groundwater overdraft (withdrawal rate greater than recharge rate).[6] Agriculture, specifically irrigation, accounts for 73 percent of Israel's current water demand. Israel's projected water demand for the year 2000 is only marginally higher than its current demand, but that figure does not account for the anticipated one million Soviet Jews likely to settle in Israel during the 1990s.[7]

Jordan

Jordan's current water demand is 900 MCM/yr, and as much as 75 percent of it originates in the Jordan River basin. This total includes approximately 150 MCM/yr withdrawn through the East Ghor Canal. Jordan is using 110 percent of its available renewable resources by overexploiting its non-renewable underground reservoirs.[8] Helena Lindholm, researcher in the Department of Peace and Development Research at the Goteberg University, estimates the demand will double to 1,800 MCM/yr by the year 2020.[9] Jordan's high population growth rate is exacerbated by the resettlement of more than 300,000 refugees from the 1990-91 Persian Gulf War.[10]

West Bank

The West Bank's current water demand is 125 MCM/yr from sources entirely within the Jordan River basin. The West Bank fully utilizes its available renewable water supplies. Palestinians use only about 15 percent of the water withdrawn from the Mountain aquifer and Israeli settlers use the remainder. The high population growth rate may worsen if Palestinian autonomy issues are resolved and the West Bank absorbs as many as 600,000 Palestinian refugees.[11] Lindholm estimates that the water demand will more than quadruple by the year 2020.[12] This estimate assumes relief from current Israeli water policies limiting Arab irrigation.

Gaza

Gaza's current water demand is 95 MCM/yr from sources entirely within the Jordan River basin. Gaza uses 150 percent of its available renewable water supplies by overdrafting the Gaza aquifer. This practice is causing increasingly severe salt water intrusion from the Mediterranean Sea. Chloride levels in Gaza City wells are often twice the acceptable level for domestic use. Kliot estimates the high population growth rate will be a leading cause in doubling the water demand by the year 2000.[13]

Syria

Syria's current water demand is interpolated from available data as 6,700 MCM/yr, and less than four percent of it originates in the Jordan River basin. Syria uses 250 MCM/yr from the Yarmuk River largely to support irrigation projects. The vast majority of Syrian water supply is from the Euphrates River and aquifers outside the Jordan River basin. Syria is currently exploiting about one-fourth of its available renewable water supply. Syria has sufficient surface, groundwater, and storage capacities to meet its current and future needs.[14] However, some of Syria's supply sources are fragile. Turkey reduced flow from its Grand Anatolia Project to Syria by 40 percent for a month in 1990 while it filled the recently completed Ataturk Dam project.[15] Syria will have to negotiate or renegotiate allocation agreements with Turkey, Iraq, Israel, Lebanon, and Jordan.

Lebanon

Lebanon's current water demand is interpolated from available data as 1,300 MCM/yr, and less than three percent of it originates in the Jordan River basin. Lebanon uses 35 MCM/yr from the Hasbani to support nearby irrigation projects. Most of Lebanon's water supply comes from the Litani River and aquifers outside the Jordan River basin. Lebanon is currently exploiting about one-fourth of its available renewable water supply. Lebanon has sufficient surface, groundwater, and storage capacities to meet its current and future needs.[16]

Notes

[1] Karl P. Magyar, ed., Global Security Concerns: Anticipating the Twenty-First Century (Maxwell Air Force Base, AL: Air University Press, March 1996), 170.

[2] Ibid. 167.

[3] Aaron T. Wolf, Hydropolitics Along the Jordan River: Scarce Water and Its Impact on the Arab-Israeli Conflict (New York: United Nations University Press, 1995), 9.

[4] Miriam R. Lowi, "Rivers of Conflict, Rivers of Peace," Journal of International Affairs 49 (Summer 1995): 133.

[5] Nurit Kliot, Water Resources and Conflict in the Middle East (London: Routledge, 1994), 243.

[6] Wolf, 11.

[7] Kliot, 243.

[8] Leif Ohlsson, ed., Hydropolitics: Conflicts Over Water as a Development Constraint (Atlantic Highlands, NJ: Zed Books, Ltd.), 59.

[9] Ibid.

[10] Wolf, 11.

[11] Ibid.

Notes

[12] Ohlsson, 59.
[13] Kliot, 244.
[14] Ibid. 222.
[15] Gleick, 88-89.
[16] Kliot, 224.

Chapter 3

History Into The Future

The wars of the next century will be over water.

—Ismail Serageldin
The World Bank

Water has been at, or near, the center of controversy between Jordan River riparians throughout history. It has led to violent conflict in some cases, added to tensions in other cases, and led to cooperation in still other cases. Thus, equating water conflict with war is a hasty conclusion. Nevertheless, it is helpful to examine the history of conflict as a baseline for projecting possible future conflict.

History of Conflict

Over 20 regional water development plans have been promulgated and failed this century for reasons other than technical feasibility. Jordan River riparian nations have a long history of conflict; this section focuses on conflicts involving water since 1947.

1947 to 1967

The period beginning with the creation of the state of Israel and ending with events that precipitated the Six Days War in 1967 is marked by violent conflict and failed attempts at resolving water conflict.

1948 War. The era of British Mandate in Palestine came to an end in February 1947 when Great Britain turned the fate of Palestine over to the newly formed United Nations (UN). The UN divided Palestine into Jewish and Arab states. British forces pulled out in May 1948, and Egypt, Jordan, Iraq, Syria, Lebanon, and Saudi Arabia promptly went to war with the new state of Israel. Water played a role in the war because one of three land areas Israel was determined to keep was the Galilee region with its Jordan headwaters. Aaron Wolf, Assistant Professor of Geography at the University of Alabama, points out that Israel lost three strategic points along waterways, causing repercussions until 1967.[1] Post-war immigration and resettlement increased Jordan's population by 80 percent and Israel's by 225 percent.[2]

Unilateral Development. A period of unilateral water development projects ensued after the 1948 war. In 1951, Israel and Jordan separately announced unilateral water development plans for the Jordan River watershed. A chain reaction of events led to skirmishes between Israel and Syria in the demilitarized zone. Then in June 1953, Jordan and Syria agreed on a plan to share the Yarmuk River waters, but Israel protested that its riparian rights were not being recognized.[3]

The Johnston Plan. United States President Eisenhower was sufficiently concerned over the issue that he appointed a special envoy in 1953 to mediate a comprehensive settlement to allocate Jordan River basin water resources. Eric Johnston made four trips to the region from 1953 to 1955, working and reworking the Unified Plan (also known as the Johnston Plan) with Israel, Jordan, Syria, and Lebanon. Miriam Lowi, author and lecturer at the Woodrow Wilson School and the Department of Near Eastern Studies at Princeton University, assesses the logic was to use technical collaboration to inspire political settlement.[4] There were good compromises on all sides, and the US and Israel recognized the plan in 1955. Israel began construction on the National Water Carrier to divert water in accordance with the Unified Plan allocations. The Arab League ultimately refused the plan in October 1955, but Jordan indirectly adopted it after receiving US aid for implementing the Ghor Plan to dam eastern tributaries to the Jordan south of the Yarmuk River.[5] Thus, Israel and Jordan began adhering to the de facto shares of the Unified Plan, but all countries continued unilateral water development projects. No other plan, before or since, has come closer to resolving the water distribution dilemma.

Arab Diversion Plan. Israel began diverting 320 MCM/yr of water through the National Water Carrier in 1964. At the same time, Jordan completed a major portion of the East Ghor Canal. An Arab Summit approved a two-stage Arab Headwater Diversion Plan in September 1964. The first stage projects would divert 125 MCM/yr of water upstream of the National Water Carrier from the Hasbani to the Litani River in Lebanon and from the Banias to the Yarmuk River in Syria. This move would effectively reduce Israel's withdrawals through the National Water Carrier. In the second stage, Arabs would develop a military plan for the ". . . liberation of Palestine from imperialism and Zionism."[6] Construction began on the Hasbani project in 1965, but the Lebanese government stopped the project in July to avert a possible Israeli attack.[7] Israel stopped the Syrian project by attacking it in March, May, and August 1965. These are just a few of the key events leading up to the Six Days War in 1967.

1967 to Present

The violent conflict in 1967 reshaped state borders and, henceforth, the hydropolitical status of the Jordan River basin nations.

The Six Days War. In May 1967, Egyptian President Nasser demanded withdrawal of UN forces from the Sinai, blockaded the Gulf of Aqaba, cutting off the Israeli port of Eilat, and declared, "The armies of Egypt, Jordan, Syria, and Lebanon are poised on the borders of Israel."[8] On 5 June, Israel attacked airfields in Egypt, Jordan, Iraq, and Syria. Six days later the war was over, and Israel took possession of the Golan Heights from Syria, the West Bank from Jordan, and Gaza and the Sanai Peninsula from Egypt. Water may not have directly influenced strategic decisions, but Israel now commanded all the Jordan River headwaters except a small portion of the Hasbani. Prior to the war, Israel was anxious for a basin-wide water accord; after the war, there was no longer any need.[9] Thomas Naff of the University of Pennsylvania concludes, "The ability of Arab riparians to proceed with unilateral (water development) schemes decreased in proportion to Israeli gains."[10]

PLO Raids. Palestinian Liberation Organization (PLO) raids against Israeli water installations peaked in 1968-69. Israel initially refrained from retaliating, but revised its policy in June 1969. Israeli air strikes on 23 June and 10 August 1969 put the East Ghor canal out of commission. This effort was designed to put pressure on Jordan's King Hussein to expel the PLO from its borders. The US mediated talks between Israel and Jordan that ultimately permitted Jordan to reconstruct the canal if they reaffirmed their adherence to Johnston Plan allocations and expelled the PLO. Jordan expelled the PLO over the next two years.[11]

1979 Drought. Tension over water heightened again during the drought of 1979. Rocks and silt built up around the intake to the East Ghor Canal. Jordan accused Israel of placing the rocks in the river to impede intake flow, and they brought forces to the ceasefire line. Israel responded in kind. US mediation prevented escalation to violent conflict. This situation typifies expected actions and reactions during extended droughts.

Lebanon Attacks. Israel attacked Lebanon in 1978 and 1982. They withdrew each time due to local resistance and international reaction. Wolf concludes that the war in 1982 had only a minor hydrologic component.[12] Nevertheless, Israel only withdrew to a self-proclaimed "security zone", giving them effective control of the Hasbani and proximity to the Litani River.[13] Water conflict researchers John Bulloch and Adel Darwish add that Israeli sources have, on a number of occasions, said Israel would withdraw from the security zone if both sides could come to an understanding on demilitarization and use of the Litani River.[14]

The Persian Gulf War. Water resources played a minor role in Jordan's political position during the Gulf War in 1990. Bulloch and Darwish cite an unidentified senior Jordanian minister who labeled water and oil as key reasons for not condemning Iraq's invasion of Kuwait. That decision preserved an agreement in principle between the two states for pumping Euphrates River water to Jordan.[15] The actual impact of water resources in Jordan's decision is questionable.

Possible Future Conflict

The cascading effects of water conflict are endless. This section focuses on a few of the most prominent hot spots. As long as demand equals or exceeds supply, every issue is viewed as a zero-sum game; that is, a gain for one is a loss for the others.

West Bank

Israel is interested in maintaining control of the West Bank because it provides strategic depth, it serves as a natural border (Jordan River versus the 1949 Armistice Demarcation Line), and it ensures control over water resources.[16] S. B. Parsons of the University of Newcastle upon Tyne identified five pressing problems concerning West Bank water. Two of those problems deal with the issue of control. First, overexploitation of groundwater has led to a partial moratorium on new well construction and emergency restrictions on water withdrawal rates in many areas. Second, control and regulation of water demand is inequitable and not administered openly.[17] Israel's West Bank water policy limits the Arab population to 18 percent of the total water available (actual use is 15 percent).[18] Lowi notes that in the Jordan Valley, Jewish settlers farm one-fourth of the cultivable area and use 45 percent of the irrigation water; Arabs farm the other three-fourths of the cultivable area and use only 55 percent of the irrigation water.[19]

Gaza

Just about every conceivable water quantity and quality problem manifests itself in Gaza, and the crisis is compounded by a burgeoning population. Parsons blames overexploitation as a root cause of increasing nitrate and salinity levels and falling groundwater levels.[20] Coupling Gaza's dense population, water quality crisis, and the highest demand-to-supply ratio in the region makes it prone to conflict.

The Yarmuk River

The Yarmuk River has lost much of its intensity as a source of conflict. Naff cited three areas of friction in the mid-1980s concerning the Yarmuk River: the high probability of water extraction in excess of de facto Johnston Plan limits; a decade of dispute over the Jordanian-Syrian plan to construct the Maqarin Dam (also known as the Unity Dam); and the East Ghor Canal intake silting problem.[21] The Treaty of Peace between Israel and Jordan, signed 26 October 1994, signals an end to this controversy. Israel's water balance remains unchanged under the treaty, but Jordan is permitted to extract an additional 40-50 MCM/yr of water from the Yarmuk River in exchange for foregoing the Unity Dam project.[22]

Notes

[1] Wolf, 43.
[2] Ibid. 44.
[3] Ibid. 45.
[4] Lowi, "Rivers of Conflict, Rivers of Peace," 130.
[5] Isaac and Shuval, 113.
[6] Wolf, 49-50.
[7] Hof, Frederic C. Galilee Divided: The Israel-Lebanon Frontier 1916-1984 (Boulder, CO: Westview Press, 1985), 36.
[8] Wolf, 51.
[9] Lowi, "Rivers of Conflict, Rivers of Peace," 134-135.
[10] Thomas Naff and Ruth C. Matson, ed., Water in the Middle East: Conflict or Cooperation (Boulder, CO: Westview Press, 1984), 44.
[11] Ibid. 45.
[12] Wolf, 82.
[13] Lowi, "Rivers of Conflict, Rivers of Peace," 128.
[14] Bulloch and Darwish, 43.
[15] Ibid. 56.
[16] Miriam R. Lowi, "Bridging the Divide: Transboundary Resources Disputes and the Case of West Bank Water," International Security 18, no. 1 (Summer 1993): 124-125.
[17] Isaac and Shuval, 498-499.
[18] Lowi, "Rivers of Conflict, Rivers of Peace," 133.
[19] Ibid, 134.
[20] Isaac and Shuval, 498-499.
[21] Naff, 53.
[22] Lowi, "Rivers of Conflict, Rivers of Peace," 140-141.

Chapter 4

Security Effects and Obstacles

> *Under severe shortage the Jordan basin water becomes a highly symbolic, contagious, aggregated, intense, salient, complicated zero-sum power and prestige packed crisis issue, highly prone to conflict and extremely difficult to resolve.*
>
> —Thomas Naff
> Testimony to Committee on Foreign Affairs,
> US House of Representatives, 1990

Lindholm applies the term "hydropolitical security complex" to describe how the transnational Jordan River defines and delimits the interrelated security concerns of each riparian nation.[1] Most experts agree it is impractical to examine the security impacts of water in isolation; rather, water is inseparable from culture, ideology, religion, politics, and economics. This chapter examines the hydropolitical security complex by breaking it down into the security effects and the obstacles to resolving water conflict.

Security Effects

University of Toronto Assistant Professor Thomas F. Homer-Dixon's review of wars since World War I indicates that states have fought over non-renewable resources more often than renewable resources. But, water is the renewable resource most likely to stimulate interstate resource war.[2] Examining two experts' models helps detail the linkage between water and national security. Homer-Dixon's model is more descriptive of intrastate conflict, while Gleick's framework is more descriptive of interstate conflict.

Homer-Dixon's Model

Homer-Dixon concludes from case study analyses that environmental scarcity causes conflict, especially in developing states. His combined model in Figure 2 shows the relationship between the sources and the consequences of environmental scarcity. The three sources might react in different patterns, but the consequence is the same: environmental scarcity.[3] Scarcity leads to a combination of migration and decreased economic productivity. Migrating groups, often from farm lands to urban areas, may cause ethnic conflict, while a decreasing economy may cause deprivation conflicts such as insurgency and rural rebellion.[4] Acting together, migration and a decreasing economy in a developing country may weaken the state's ability to control opportunists' challenges against authority.[5]

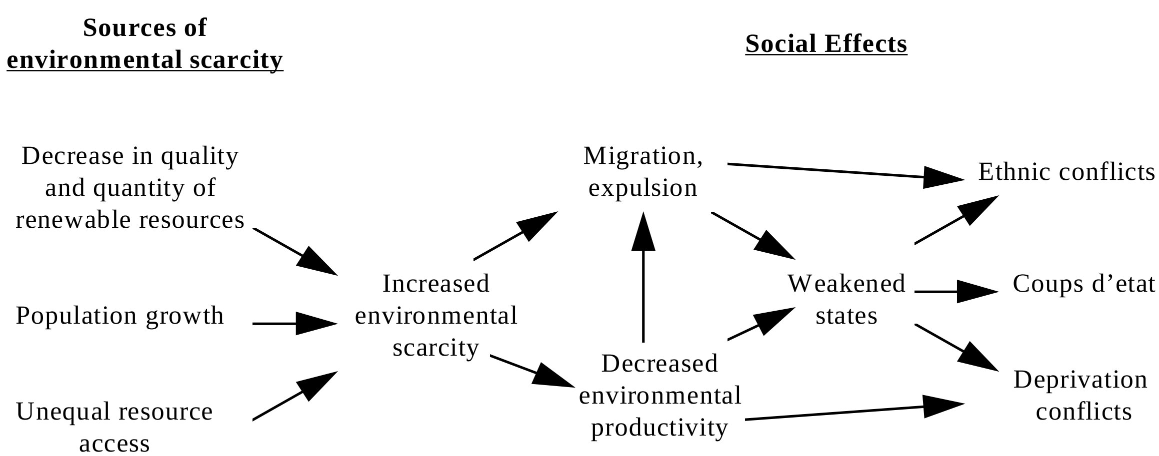

Figure 3. Homer-Dixon's Combined Model

Gleick's Framework

Gleick identifies two classes of water-related disputes that play a role in interstate conflict. The first class is "water resources as political and military goals." If water is a source of political or economic strength, then ensuring its access is "…a justification for going to war, and water-supply systems can become a goal of military conquest."[6] He identifies four conditions that dictate the intensity of strategic rivalry over water: the degree of scarcity; the extent to which the water supply is shared by more than one region or state; the relative power of the basin states; and, the ease of access to alternative fresh water sources.[7] Wolf uses the label "hydraulic imperative theory" to describe the extreme case of these conditions, whereby water resources become the primary motivator for Israeli military conquests.[8] While Wolf's research concludes there is no hydrologic basis to support the hydraulic imperative in the Jordan River basin, Gleick's framework shows how water resources can be a contributing factor to conflict.

The second class is "water resource systems as instruments of war", primarily as targets. Hydroelectric plants, water treatment facilities, and storage facilities are examples of strategic targets. For example, recall that Israel bombed Jordan's East Ghor Canal in 1969 to pressure King Hussein to take action against the PLO.

Obstacles to Resolving Water Conflict

The theoretical linkage between water resources and national security sets the stage for discussing specific obstacles to resolving water conflict in the Jordan River basin. A complete listing of the possible cultural, ideological, religious, political, and economic obstacles is probably inexhaustible. This section focuses on five of the most prominent obstacles to resolving the water conflict.

History of Conflict

It is difficult to break the pattern of centuries of conflict over such issues as boundaries, resources, and sovereignty. Water conflict is one piece of the puzzle; it cannot easily be separated from the whole, resolved in a vacuum, and then be placed back into the puzzle. The twenty or so failed attempts during this century to develop multilateral water development schemes amply prove this point. Water, like most issues in this region, is viewed as a zero-sum game.

The lack of trust between basin neighbors fosters a lack of hydrologic data sharing. Data on surface and groundwater supply and demand are held close. In fact, Gleick reports that Israel classifies as secret some water data, especially in the Occupied Territories.[9] No solution is possible until the problem is adequately quantified.

Management by State Boundaries

The Jordan River and its headwaters, the Yarmuk River, and the Mountain Aquifer are key basin components that are also transboundary sources. States control and exploit the water that flows through, or discharges within, their borders. Simultaneously, states try to influence the flow of water through upstream riparians. Since the water is not managed at the watershed level, it is poorly distributed between users. The Maqarin Dam proposal mentioned in Chapter 2 exemplifies this point. The project would have allowed Jordan to capture some of the winter runoff for irrigation and hydroelectric generation, but the Israelis threatened to destroy it, if built, because they feared Jordan and Syria would conspire to withhold water from reaching the lower Jordan River.

International Law

Two bodies of international law have failed to adequately address transboundary water issues. In fact, their works present a troubling dichotomy. Article IV of the International Law Association's 1966 Helsinki Rules stresses the principle of "reasonable and equitable share." This article could be interpreted to ensure new and future users receive an equitable share of the water resources. The International Law Commission, bound by UN General Assembly directives, stresses the principle of not inflicting harm on present users. Leif Ohlsson, Professor of International Relations and Development Studies at Goteberg University in Stockholm, contends this principle encourages "…a 'race for the river', where the first user will possess all the rights."[10]

Islamism and Zionism

Water plays a key role in Islamism and Zionism. Arab countries are generally administered according to Islamic law, or the sharia. Water is central to Islamism, and the "…sharia holds that water is a gift from God that should not be owned or controlled to the point of excluding others from using it.…"[11] The sharia has different rules for rivers, springs, and wells. In general, if adequate supplies are available, they should be shared with no one having the right to exclude others from their use. If adequate supplies are not available, storage facilities should be built, and water should be shared by those living in the vicinity, with priority going to those who contributed to building the storage facility.

Zionism is defined as the plan or movement for maintaining a Jewish national or religious community in Israel. The Zionists' primary concern for water resources is that they be used to benefit the Jewish community. For example, water resource distribution decisions in the West Bank favor Jewish settlers. Since 1967, Mekerot (the Israeli water company) has drilled more than 30 wells for Jewish settlers' irrigation needs, but none for Arab agricultural needs.[12]

Agricultural Self-Sufficiency

Studies project that water use for agriculture must drop from the present 73 to 84 percent down to 60 percent to account for increasing population demands. Significant improvements have been made to increase the efficiency of irrigation systems, but they are not enough. Many experts question why governments continue to subsidize (charge less than the actual value) water supplies for agriculture. An article in Middle East Insight magazine offers two reasons for government subsidies. First, they are concerned about the security of their food supply. Nevertheless, states will inevitably become less self-sufficient as populations increase. Peace activist Boaz Wachtel adds it will be difficult to overturn the desire for states to be self-sufficient in food supply without simultaneously assuring affordable and secure food imports.[13] Second, supporting a rural economy stops the flow of people to cities, thereby mitigating a host of other problems.[14]

Notes

[1] Ohlssson, 58.

[2] Sean M. Lynn-Jones and Steven M. Miller, ed., Global Dangers: Changing Dimensions of International Security (Cambridge, MA: The MIT Press, 1995), 157-159.

[3] Ibid. 147-149.

[4] Ibid. 170-174.

[5] Ibid.

Notes

[6] Gleick, 84.

[7] Gleick, 84-85.

[8] Wolf, 70-72.

[9] Gleick, 108.

[10] Ohlsson, 25.

[11] Bulloch and Darwish, 173-174.

[12] Lynn-Jones and Miller, 153.

[13] Boaz Wachtel, “From Peace Pipelines to Peace Canals,” Middle East Insight 10 (November-December 1993): 26.

[14] “Dry Politics,” 5.

Chapter 5

Technology Solutions

> *This is a time bomb, and if the peoples of the region are not clever enough to discuss a mutual solution for the problem of water scarcity, then war is unavoidable.*
>
> —Meir Ben-Meir
> Former Director of the Israeli Agriculture Agency

The scientific community is actively engaged in seeking solutions to water quantity and quality problems in the Jordan River basin. Academics and engineers from basin countries and foreign countries are working on solutions to increase the supply of usable water and control the demand for it. Some solutions have been fielded for decades, with marginal to fair results, but more needs to be done to keep pace with current and projected demand. One thing is for sure—any solution must be politically acceptable to be viable. This chapter focuses on the prerequisites for viable solutions and an analysis of the merits of three promising technology-based solutions.

Prerequisites

At least 20 water development schemes for the Jordan River basin have failed during this century, at least in part because they were politically or culturally unacceptable. Cooperation and a shift toward demand management are two prerequisites for any technological solutions to have an impact.

Cooperation

Political and scientific experts agree that water and peace are interdependent. A viable water development scheme relies on a peace accord among the basin states and nations. Likewise, a peace accord needs to be supported, in part, by a viable water development scheme. The dilemma is converting the water crisis from a zero-sum situation to an environment of cooperation. Kally believes cooperation is the only chance until technology and economic options become feasible and relevant.[1] Lowi suggests that some measure of cooperation can be achieved by creating a supranational authority for basin-wide water management.[2] The first task of the authority would be to gain access to water data and establish agreement over supply and demand facts. Gleick concurs with the cooperative management idea and adds that such an authority must have some type of codified mechanism for conflict resolution.[3]

There are signs of cooperation in the 1990s. Water was one of five substantive issues discussed at the Middle East Peace Conference in Madrid in the fall of 1991. A water resources working group was chartered to begin working cooperative water solutions throughout the Middle East. Then, in September 1993, Israel and the PLO signed the Declaration of Principles on Interim Self-Government Arrangements. Israeli Prime Minister Rabin and PLO Chairman Arafat committed to cooperate on water issues and to establish a Palestinian Water Administrative Authority.[4] Since that time, the working group created in 1991 has made significant progress in developing joint water projects for the long-term.[5] Most recently, the 1994 Treaty of Peace between Israel and Jordan, discussed in Chapter 3, contained provisions for usage of the Yarmuk River. These steps forward must continue to be reflected in national politics to have any lasting impact. Also, bilateral agreements need to be expanded into multilateral agreements to have an overall impact on the basin water balance.

Demand Management

Most solutions concentrate on increasing water supply, but a simultaneous effort to control water demand is equally critical. Naff identified 13 specific measures to institute a demand-side strategy. His proposals include:

1. Population control
2. Education
3. Reducing water subsidies and increasing irrigation efficiencies in agriculture
4. Encouraging cooperation at sub-national levels among officials and technical experts.[6]

Wolf's demand-side strategies are a subset of Naff's proposals, but he adds that items 1 through 3 can all be enacted unilaterally.[7]

Professor Hillel Shuval of the Truman Institute for the Advancement of Peace of the Hebrew University takes a different approach to demand management. He recommends establishing a Minimum Water Requirement (MWR) of 125 m^3/pn/yr, plus an additional 65 m^3/pn/yr for water recycling and reuse.[8] The MWR would serve as a baseline for negotiating water allocations for each country based on population. Using this method, he projects Syria, Lebanon, and Israel would have water surpluses in the year 2020; whereas, Jordan and the Palestinians would have deficits. Then, water redistribution should be considered based on historical use, volume rises in upstream territories, alternate water sources, and legitimate present and future needs.[9] Shuval's proposal requires adaptation, but it certainly provides a foundation for cooperation and demand management.

Supply-Side Solutions

Technological solutions to increase the supply of water in the Jordan River basin can alleviate the crisis, but they cannot eliminate it. This section will discuss the relative merits of three of the most promising technological solutions: desalination, reclamation, and interbasin transfers. These solutions are significant because they reflect conversion, reuse, and cooperation.

Desalination

Desalination is the process of converting seawater or brackish water into potable water for domestic, agricultural, and irrigation uses. Desalination plans date back to the 1960s, and a variety of processes have emerged to improve cost effectiveness. Hoffman, an Israeli engineer and researcher, states the most relevant processes today are reverse osmosis (RO) and low temperature multi-effect distillation (LT-MED).[10] RO uses pressure driven semi-permeable membranes to separate salt out of the water, and different processes have evolved based on the degree of salinity of the raw water. LT-MED is a seawater distillation process that uses alternating evaporation and condensation cycles to remove salt. This section addresses RO desalination as a general category.

Merits. First, desalination is the only technology that converts seawater into fresh water. It is the *only* solution when no fresh water alternatives exist. Second, RO can improve both the quantity and quality of available water. The quantity benefit is obvious since the Mediterranean Sea is readily accessible. The quality benefit is important since the Jordan River becomes increasingly saline as it flows south toward the Dead Sea. Also, overpumping is steadily increasing groundwater salinity, especially the Gaza aquifer.

Third, desalination improves a state's self-sufficiency for supplying water. Desalination can lessen a state's reliance on shared water resources and bilateral water agreements. Fourth, variations of desalination technologies have emerged which are more cost effective in treating brackish water. Finally, more than three decades of experience in desalination is available. Wolf suggests using the Agro-Industrial Complex (US supported project in the 1960s) and the Mediterranean Sea-Dead Sea Canal (Israeli project in the 1980s) projects as the basis for a 1990s project.[11]

Drawbacks. Desalination is capital- and energy-intensive. Masahiro Murakami, a senior research engineer and doctoral expert on the Jordan River system, maintains that while the cost of desalinating brackish water is competitive, the cost of desalinating seawater is three to five times higher.[12] Hoffman's study of four projects showed a product cost ranging from US$0.27/m^3 for brackish water to US$1.16/m^3 for seawater. Cost will fluctuate with energy cost. Desalinating Mediterranean Seawater in Gaza, for example, may be too costly. An economic model developed by American, Israeli, Palestinian, and Jordanian experts working with the Harvard Middle East Water Project concludes desalination is unlikely to become economical on the Mediterranean coast before 2020.[13] A hydro-power scheme to co-generate power and desalinated water can mitigate the operating cost of a desalination plant. A secondary drawback to desalination is the potential vulnerability of a desalination plant as a target for violent conflict. Virtually all water production or storage structures would share this vulnerability.

Wastewater Reclamation

Wastewater reclamation is the process of reclaiming domestic and industrial wastewater, treating it, and reusing it for irrigation. It is a simple technology commonly used in developed countries.

Merits. First, wastewater reclamation helps protect the environment, especially groundwater supplies. In areas not served by sewage collection systems, septic tanks discharge their effluent into the ground, thereby endangering groundwater supplies. Reclamation makes more efficient use of existing resources rather than focusing on increasing the capacity of hydraulic structures.[14] Second, reclamation is a solution perfectly suited for agriculture-based economies with high irrigation requirements. As populations increase in the Jordan River basin, so does the volume of domestic sewage. This somewhat marginal solution could become a significant contributor to irrigation water supplies. The Water Authority of Jordan expects to collect 116 MCM/yr in north Jordan by the year 2004, most of which will be used for downstream irrigation in the Jordan valley.[15] Similarly, Israel currently treats 110 MCM/yr for reuse. Third, like desalination, reclamation improves a state's self-sufficiency in meeting its water demand.

Drawbacks. There are public health concerns associated with plant uptake of reclaimed wastewater. This technology must be closely controlled to minimize the risk to agriculture consumers. Also, wastewater reclamation is limited by the extent of municipal sewage collection. Jordan has significantly improved its sewage collection infrastructure over the past decade, yet it serves only 40 percent of the urban population (25 percent of the total population).[16] The percentage for Israel is closer to 80 percent.[17]

Interbasin Water Transfer

Interbasin water transfer includes any mode of transporting water from a source outside the Jordan River basin into the basin for storage and use. This section looks at the more common modes of transport: canals and pipelines. Kally, Wolf, and Lindholm generally agree on the following four interbasin transfer schemes, although they may prioritize them differently based on need and economics:

1. Yarmuk River to the Sea of Galilee—store winter run-off for use in the West Bank and Jordan (eliminates need for Maqarin Dam, decreases Sea of Galilee salinity)[18]
2. Nile River to Gaza (Israel could offer hydrotechnology in exchange for agreement by Egypt, Sudan, and Ethiopia)[19]
3. Litani River to the West Bank
4. Scaled down Peace Pipeline (Wachtel Plan: 1,100 MCM/yr from Ataturk Baraji Lake distributed equally between Israel, Jordan, Syria, and the Palestinians)[20]

Merits. The most obvious benefit of interbasin water transfers is that they increase the water supply without exploiting Jordan River basin resources. Second, interbasin water need not be viewed as a zero-sum situation; that is, more water for one does not mean less water for another. Distribution decisions can be made based on legitimate needs rather than riparian status. Third, interbasin transfers could cost less than desalination in some locations. Kally compared the Nile to Gaza canal transfer option to seawater desalination and found desalination to cost US$0.23/m^3 more than the transfer option.[21] Finally, interbasin transfers spur opportunities for cooperation. For example, water transferred from the Nile to Gaza and Israel could enable Israel to apportion some of its Jordan River share to West Bank Palestinians, a process called exchange.

Drawbacks. First, interbasin transfers require the approval of all states involved, even those affected only by a pipeline crossing their territory.[22] This could be a show stopper without the prerequisite spirit of cooperation. Second, this solution promotes a state's dependency rather than improving its self-sufficiency. The provider can leverage its ability to shut off the water in order to make other political gains. Third, canals and pipelines are potential targets for violent conflict. Shuval argues that all these concerns can be lessened by the proper combination of pipelines or canals and exchanges.[23]

Notes

[1] Kally, 23.
[2] Lowi, "Rivers of Conflict, Rivers of Peace," 126.
[3] Isaac and Shuval, 46,49.
[4] Ohlsson, 88-89.
[5] Lowi, "Rivers of Conflict, Rivers of Peace," 139-140.
[6] Isaac and Shuval, 89-90.
[7] Wolf, 130-131.
[8] Isaac and Shuval, 489.
[9] Ibid. 486.
[10] Isaac and Shuval, 317.
[11] Wolf, 91, 161-163.
[12] Masahiro Murakami, Managing Water for Peace in the Middle East: Alternative Strategies (New York: United Nations University Press, 1995) 6, 197.
[13] Franklin M. Fisher, "Water and Peace in the Middle East," Middle East International 513 (17 November 1995): 17.
[14] Murakami, 7.
[15] Ibid. 182.
[16] Ibid. 173.
[17] Wolf, 92.
[18] Kally, 75.
[19] Wolf, 150.
[20] Isaac and Shuval, 363.
[21] Kally, 114.
[22] Ohlsson, 87.
[23] Isaac and Shuval, 487-488.

Chapter 6

Summary and Conclusions

The Jordan River basin is located in one of the most volatile regions in the world. The basin is relatively small in terms of geography and flow, but water has become the most precious resource in the region. The competition for water has led to violent conflict or compounded existing tensions throughout this century. In both cases, there is a definite connection between water and security.

Summary of Key Findings

The obstacles to solving water conflict are significant, but not insurmountable. It is important to understand how history, management by state boundaries, international law, Islamism and Zionism, and agricultural self-sufficiency have effectively blocked every mutually beneficial water development scheme proposed this century. It is more important, however, to use those lessons to help solve the current and projected water crisis. Despite increasing water scarcity in the 1990s, there are signs that water can also be a force for cooperation in the basin. Water was a substantive issue in bilateral agreements signed by Israel and the PLO in 1993 and Israel and Jordan in 1994.

Technology can help solve the water crisis, given the necessary prerequisites. A viable water development scheme demands the cooperation of all basin governments. History shows that anything less than a broad peace accord may be insufficient. A shift toward demand management is also necessary to begin solving the crisis. Water is finite, so current and projected usage must be examined and changed where appropriate.

Desalination, wastewater reclamation, and interbasin transfers are three of the most promising supply-side solutions. None of these technologies alone can solve the water crisis, but in combination they can have a significant impact. Each technology has its particular merits and drawbacks. The key is to apply each technology in the right situation to capitalize on its benefits, while mitigating potential side effects.

Conclusions

The Gaza aquifer could become brackish in the next five to ten years unless Israel and the Palestinians take urgent, joint action. Water quality and quantity problems are immediate and severe. Chloride levels in the Gaza aquifer are already double the acceptable standard for domestic use, yet Gaza continues to overdraft the aquifer by more than 50 percent annually to meet a growing demand. Public health and economic survival are at risk. Losing the aquifer as a freshwater source could push Gaza toward the deprivation conflicts described in Homer-Dixon’s model. Israel and the Palestinians need to focus on population control, increasing water supplies, and improving domestic sewage collection and reuse. Gaza is an ideal location for a pilot cooperative desalination project. Israel and the Palestinians should also investigate an interbasin pipeline project with Egypt, Ethiopia, and Sudan to transfer water from the Nile River to Gaza. These infrastructure projects are probably cost-prohibitive without external financial support.

Water quality is not a problem in the West Bank, and the water quantity problem is slightly less severe than in Gaza in the near term. The final outcome of current Palestinian autonomy negotiations will impact Arabs and Israelis alike, since 25 percent of Israel's total freshwater supply originates in the West Bank. Israel's water policy limiting Arab water use needs to be reviewed as part of the autonomy negotiations. They need to institute better demand management practices through the Palestinian Water Administrative Authority. Shuval's Minimum Water Requirement concept could be used to establish a baseline for allocating water equitably, focusing on domestic and agricultural use. Israel and the Palestinians also need to examine ways to control population growth in the West Bank.

The water dilemma will not reach crisis proportions in Israel or Jordan in the next decade. These two states should take a joint leadership role now to avert a severe water crisis throughout the basin that will inevitably occur if they stay on their current course. They should use their 1994 Treaty of Peace as a foundation for expanding bilateral agreements into multilateral agreements in the region. They should also jointly research innovative applications for desalination and interbasin transfers and commit to carrying out projects. Finally, they should examine the future impact of current population growth rates and take appropriate action.

Further Study

This study leaves two primary areas for further investigation: demand management and economic analysis. Greater emphasis is needed in managing water demands from a basin-wide perspective, especially for irrigation. Also, the supply-side solutions discussed in this paper need to be compared economically. Existing cost-benefit models help determine the right solution for the right circumstance, but they may need to be tailored to account for a government's action to subsidize agriculture. An economic analysis may also reveal opportunities for a government to offer incentives to the engineering community for developing the right solutions.

Glossary

aquifer. An underground, water-bearing rock formation. Most aquifers are considered to be renewable water sources.

arid. A climate region that receives less than 10 inches of rainfall annually.

Armistice Demarcation Line. International borders, agreed upon in 1949, dividing Israel, Jordan, Syria, and Lebanon. These borders remained in effect until 1967.

fossil water. See non-renewable water.

Gaza or Gaza Strip. One of the Occupied Territories, located on the Mediterranean coast, bordering Egypt. It is Israeli-occupied with interim status allowing some degree of autonomy, pending final negotiations between Israel and Palestinians.

Golan Heights. One of the Occupied Territories, adjacent to the northeast border of Israel. The Golan Heights also share borders with Jordan, Syria, and Lebanon.

Green Line. See Armistice Demarcation Line.

hydropolitics. A general term describing the political ramifications of water access and control, including water conflict.

Islamism. The religious faith based on the teachings of the prophet Mohammed.

non-renewable water. A deep groundwater source that takes thousands of years to recharge. Non-renewable water sources do not readily recharge through infiltration.

Occupied Territories. Gaza Strip, West Bank, and Golan Heights.

renewable water. A groundwater source that recharges through infiltration. Most aquifers are renewable water sources.

riparian. A state whose interior land or borders constitute the bank of a river.

semi-arid. A climate region that receives between 10 inches and 20 inches of rainfall annually.

sharia. Codified Islamic law.

wadi. A side stream that carries little or no water except during seasonal periods of high rainfall or run-off.

West Bank. One of the Occupied Territories, bordering Jordan. It is Israeli-occupied with interim status allowing some degree of autonomy, pending final negotiations between Israel and Palestinians.

Zionism. The plan or movement for maintaining a Jewish national or religious community in Israel.

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Air Command and Staff College
Maxwell AFB, Al 36112