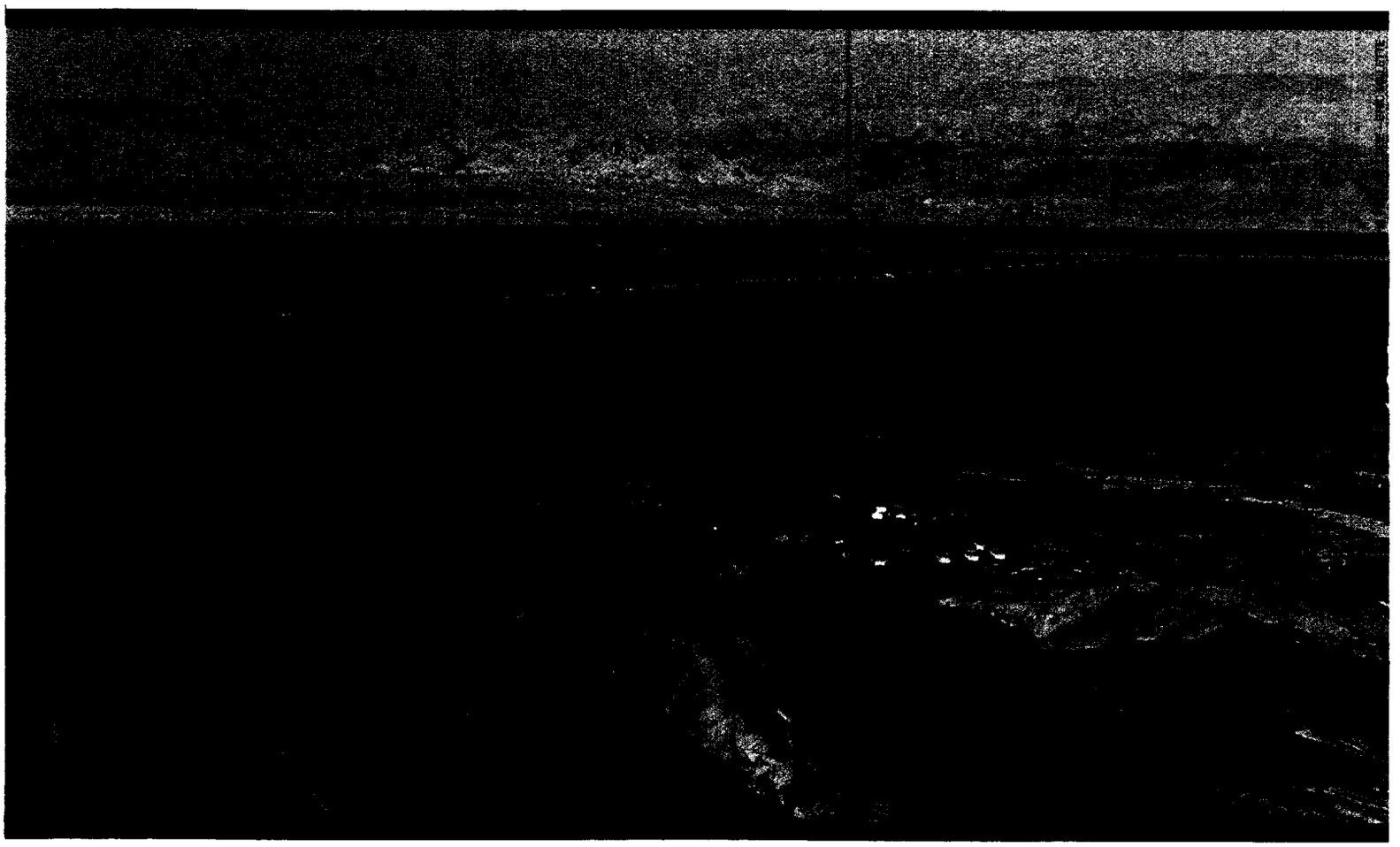
Water, war & peace in the Middle East
Gleick, Peter H; Yolles, Peter; Hatami, Haleh
Environment; Apr 1994; 36, 3; ProQuest Direct Complete
pg. 6

As the 21st century approaches, population pressures, irrigation demands, and growing resource needs throughout the world are increasing the competition for freshwater. Nowhere is this more evident than in the arid Middle East, where the scarcity of water has played a central role in defining the political relationships of the region for thousands of years. In the Middle East, ideological, religious, and geographical disputes go hand in hand with water-related tensions, and even those parts of the Middle East with relatively extensive water resources, such as the Nile, Tigris, and Euphrates river valleys, are coming under pressure. Competition for the limited water resources of the area is not new; people have been fighting over, and with, water since ancient times. The problem has become especially urgent in recent years, however, because of increasing demands for water, the limited options for improving overall supply and management, and the intense political conflicts in the region. At the same time, the need to manage jointly the shared water resources of the region may provide an unprecedented opportunity to move toward an era of cooperation and peace.



During the last two years, water conflicts have become sufficiently important to merit separate explicit discussion in both the multilateral and bilateral Middle East peace talks now under way (see the box on page 8). Among the issues that must be resolved are the allocation and control of water in, and the water rights to, the Jordan River and the three aquifers underlying the West Bank; a dis-

WATER, WAR & PEACE in the MIDDLE EAST

By Peter H. Gleick

pute between Syria and Jordan over the construction and operation of a number of Syrian dams on the Yarmuk River; the joint management of the Euphrates River between Turkey, Syria, and Iraq; and how to protect water quality for all those dependent on these resources.

Conflicts among nations are caused by many factors, including religious differences, ideological disputes, arguments over borders, and economic competition. Although it is difficult to disentangle the many intertwined causes of conflict, competition over natural resources and disputes over environmental factors are playing an increasing role in international relations.[1]

These conflicts can take several forms, including the use of resources or the environment as instruments of war or as goals of military conquest. History reveals that water has frequently provided a justification for going to war: It has been an object of military conquest, a source of economic or political strength, and both a tool and target of conflict. Also, on occasion, shortages of water have constrained a country's economic or political options.[2] No region has seen more water-related conflicts than the

PETER H. GLEICK is director of the Global Environment Program of the Pacific Institute for Studies in Development, Environment, and Security, based in Oakland, California. Partial support for the Middle East Water project of the institute has been provided by the Ploughshares Fund.

Middle East, and some of these go back more than 5,000 years to the earliest civilizations in Mesopotamia (see the box on pages 10 and 11).

Water can become a source of strategic rivalry because of its scarcity, the extent to which the supply is shared by more than one region or state, the relative power of the basin states, and the ease of access to alternative freshwater sources. In the Middle East, water is scarce and widely shared by countries with enormous economic, military, and political differences. Also, there are few economically or politically acceptable alternative sources of supply. Thus, the temptation to use water for political or military purposes has often proved irresistible. As water supplies and delivery systems become increasingly valuable in water-scarce regions, their value as military targets increases.

In modern times, the most pressing water conflicts in the Middle East have centered on control of the Jordan River basin, apportionment of the waters of the Euphrates and Nile Rivers, and management of the groundwater aquifers of the occupied territories.

The Water Resources

The water resources of the Middle East are unevenly distributed and used, and every major river in the region crosses international borders. Table 1 on page 13 identifies the major river basins in the region and the countries that are part of those basins. The extent to which major rivers and groundwater basins are shared by two or more nations makes the allocation and sharing of water a striking political problem and greatly complicates the collection and dissemination of even the most basic data on water availability and use. In northeast Africa and the Middle East, more than 50 percent of the total population relies upon river water that flows across a political border. Two-thirds of all Arabic speaking people in the region depend upon water that originates in non-Arabic-speaking areas; two-thirds of Israel's freshwater comes from the occupied territories or the Jordan River basin; and one-quarter of the Arab people live in areas entirely dependent on nonrenewable groundwater or on expensive, desalinized seawater.[3]

The major shared surface water supplies in the Middle East are the

WATER AND THE MIDDLE EAST PEACE TALKS

By Peter Yolles and Peter H. Gleick

Water is such an important aspect of the international relationships in the Middle East that it has been made an explicit part of the ongoing peace talks. There are two tracks to these talks, the bilateral talks and the multilateral talks. The official goal of the bilateral negotiations is a "just, lasting, and comprehensive peace."[1] These talks are where the major political questions are being worked out in meetings between Israel and each of the other interests in the area. The major water issues in the bilateral talks are defining and securing appropriate shares of water rights. Discussion of the prime question of control of water and water rights was originally part of the multilateral talks but was recently moved to the bilateral talks. In the Israeli-Jordanian bilateral talks, a subcommittee on "Water, Energy, and Environment" was formed, and a subcommittee on "Land and Water" has been formed for the Israeli-Palestinian talks.

There are five separate working groups in the multilateral talks: Refugees, Arms Control and Regional Security, Economic Development, Environment, and Water. A steering committee oversees the work of these groups and provides links with the ongoing bilateral talks. In the water talks of the multilaterals, practical questions of regional cooperation are under discussion with all interested governmental parties. These questions include how to alleviate short-term and long-term water shortages, how to increase overall water supplies, and what institutions could enhance data sharing, conflict resolution, and river basin management. Four sets of multilateral water negotiations have already been held in Vienna (May 1992), Washington, D.C. (September 1992), Geneva (April 1993), and Beijing (October 1993). The next set is being held this month in Oman. The water track of the multilaterals is the only one to have successfully produced a signed agreement: to cooperate on a series of formal and informal "activities" around supply questions, data sharing, and institution building. These activities began in summer 1993 and are continuing.

In addition to the formal peace talks now under way, there is an informal track of separate independent, unofficial discussions. These are often academic meetings, workshops, and conferences. Among the recent meetings have been an Israeli-Palestinian conference in Zurich in December 1992; an academic workshop on the multilaterals held at the University of California at Los Angeles in April 1993, which included delegates from Jordan, Israel, and the Palestinians; a meeting in Champagne/Urbana, Illinois, sponsored by the International Water Resources Association in October 1993; and a Pugwash Conference on Middle East issues held outside of Stockholm in December 1993.

These meetings provide an unofficial forum for broaching ideas and exchanging information, and they are considered extremely fruitful both for the ideas that are raised and for the relationships that are formed. Several of the ideas that have made their way into the recent formal agreements between Israel and the Palestinians and Israel and Jordan originated at these unofficial meetings. These ideas include the goal of equitable utilization, the supply of minimum water requirements to existing inhabitants, and the need to examine certain new supply options.

PETER YOLLES is a research assistant at the Pacific Institute for Studies in Development, Environment, and Security, based in Oakland, California. **PETER H. GLEICK** is the director of the Pacific Institute's Global Environment Program.

1. Reuters, *Draft Agenda of the Israeli-Jordanian Delegation to the Peace Talks, October 27, 1992* (1 November 1992).

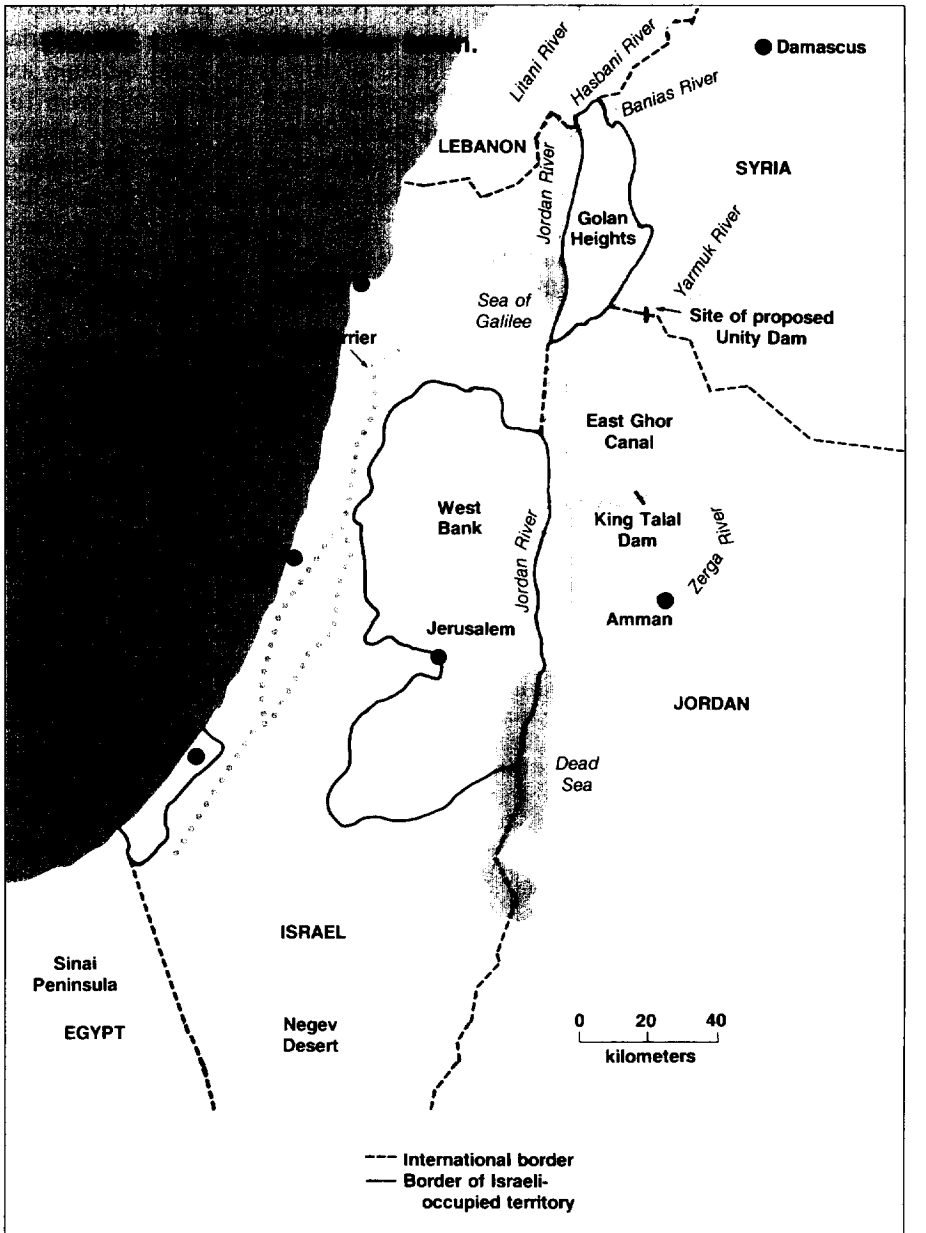
Jordan, Tigris, Euphrates, and Nile Rivers. Although the watershed of the Litani River lies entirely within Lebanon, control and allocation of its waters remain controversial. Several major groundwater aquifers are also heavily used and, in the occupied territories, strongly contested.

In the Middle East, actual water availability fluctuates dramatically both seasonally and from year to year. For many of the major rivers of the region, flows in dry years may be as low as one-half to one-third the volume of the average yearly flows, and there is a long history of persistent and severe droughts.[4]

Water quality problems also affect the region. Heavy use of water for irrigation contaminates water with agricultural chemicals and salts and reduces the quality of water for downstream users. Overpumping from many underground aquifers is leading to the intrusion of saltwater and the contamination of remaining supplies—a problem especially evident in the coastal aquifers of the Gaza Strip.

The Jordan River

Despite its small size, the Jordan River is one of the most important in the region and the locus of intense international competition (see Figure 1 on this page). Shared by Jordan, Syria, Israel, and Lebanon, the Jordan drains an area of slightly less than 20,000 square kilometers and flows 360 kilometers from its headwaters to the Dead Sea. Annual precipitation in the watershed ranges from less than 50 millimeters per year to more than 1,000 millimeters per year and averages less than 200 millimeters per year,[5] which is insufficient for most rainfed agriculture. The upper Jordan is fed by three major springs, the Hasbani in Lebanon, the Banias in Syria, and the Dan in Israel. The major tributary of the Jordan, the Yarmuk River, originates in Syria and Jordan and constitutes part of the border between these countries and the Israeli-occupied Golan Heights before flowing into the Jordan River. The quality of Jordan River water is very good up to the point where it enters Lake Tiberias (also known as the Sea of Galilee); by the time it enters the Dead Sea, the water remaining in the Jordan has become too salty to use.



SOURCE: Redrawn from a map of the General Staff Map Section, Director General of Military Survey, Ministry of Defence, United Kingdom, 1991.

Total average unimpaired flow of the Jordan River is about 1,850 million cubic meters per year (m^3/y). Israel normally uses 1,600 million to 1,800 million m^3/y from all sources, including around 600 million m^3/y from the Jordan River; about 800 million m^3/y from groundwater aquifers; and 360 million m^3/y from reuse of wastewater. Jordan has usually derived between 700 million and 900 million m^3/y of usable water from all sources, including groundwater, the Yarmuk, and a few other small surface sources.[6]

Additional population growth in this region is expected to be high: Even without immigration, Jordan's and Syria's populations are growing at around 3.5 percent per year, and Israel's is growing at about 1.7 per-

cent per year (see Table 2 on page 15). Immigration of Soviet and other Jews and of Palestinians either displaced from other lands or returning to the region may add several million more people by the early 21st century.

Since the establishment of Israel in 1948, this basin has been the center of intense international conflict, and the dispute over the waters of the Jordan River is an integral part of the ongoing conflict. In the 1950s, when Syria tried to stop Israel from building its National Water Carrier, a system to provide water to southern Israel, fighting broke out across the demilitarized zone. When Syria tried to divert the headwaters of the Jordan away from Israel in the mid-1960s, Israel used force, including air strikes against the diversion facilities.[7] These military actions contributed to the tensions that led to the 1967 Arab-Israeli War, the occupation of the West Bank, and control over much of the headwaters of the Jordan River by Israel.

Tensions also exist in the Jordan basin between Syria and Jordan over the construction and operation of a

CONFLICTS OVER WATER IN THE MYTHS, LEGENDS, AND ANCIENT HISTORY OF THE MIDDLE EAST

By Haleh Hatami and Peter H. Gleick

The history of water-related disputes in the Middle East goes back to antiquity and is described in the many myths, legends, and historical accounts that have survived from earlier times. These disputes range from conflicts over access to adequate water supplies to intentional attacks on water delivery systems during wars. A chronology of such water-related conflicts in the Tigris and Euphrates river valleys during the last 5,000 years appears on the facing page.[1]

One of the earliest examples of the use of water as a weapon is the ancient Sumerian myth—which parallels the Biblical account of Noah and the deluge—recounting the deeds of the diety Ea, who punishes humanity's sins by inflicting the Earth with a great flood. According to the Sumerians, the patriarch Utu speaks with Ea, who warns him of the impending flood and orders him to build a large vessel filled with "all the seeds of life."[2]

A dispute between the city-states of Umma and Lagash over the fertile soils of Mesopotamia between the modern-day Tigris and Euphrates Rivers continued from 2500 to 2400 B.C. and included conflicts over irrigation systems and the intentional diversion of water supplies. Continuing disputes over water in the region later led Hammurabi of Babylon (around 1790 B.C.) to include several laws in the famous "Code of Hammurabi" pertaining to the negligence of irrigation systems and to water theft.

Many Biblical accounts include descriptions of the use of water as an instrument of conflict, including the banishment of Hagar and Ishmael to the wilderness with only a limited amount of water and their divine salvation when God leads them to a well (Genesis 21:1-23). According to Islam, Ishmael's offspring constitute the nation of Islam; a similar Qur'anic verse parallels this Biblical account. The well, called Zum Zum, is thought to be located at Mecca. Exodus recounts the miracle of Moses parting the Red Sea or, alternatively, damming a tributary of the Nile to prevent the Egyptians from reaching the Jews as they journeyed through the Sinai.[3] In Chronicles 32:3, Hezekiah digs a well outside the walls of Jerusalem and uses a conduit to bring in water to prepare for a siege by Sennacherib. By cutting off water supplies outside of the city walls, Jerusalem survives the attack.

HALEH HATAMI is a research assistant at the Pacific Institute for Studies in Development, Environment, and Security, based in Oakland, California. **PETER H. GLEICK** is the director of the Pacific Institute's Global Environment Program.

PHOTOGRAPHERS/ASPEN—JONATHAN WRIGHT

Ruins of a Sumerian city in Iraq

Other historical accounts offer fascinating insights into the role of water in war and politics. Sargon II, the Assyrian king from 720 to 705 B.C., destroyed the intricate irrigation network of the Haldians after his successful campaign through Armenia. Sennacherib of Assyria devastated Babylon in 689 B.C. as retribution for the death of his son and intentionally destroyed the water supply canals to the city. Assurbanipal, King of Assyria from 669 to 626 B.C., seized water wells as part of his strategy of desert warfare against Arabia. According to inscriptions recorded during the reign of Esarhaddon (681-669 B.C.), the Assyrians besieged the city of Tyre, cutting off food and water. In another account, in 612 B.C., a coalition of Egyptian, Median (Persian), and Babylonian forces attacked and destroyed Ninevah, the capital of Assyria, by diverting the Khosr River to create a flood.

Nebuchadnezzar (605-562 B.C.) built immense walls around Babylon and used the Euphrates River and a series of canals as defensive moats surrounding the inner castle. Describing Nebuchadnezzar's plan to create an impregnable city, the ancient historian Berossus states, "He arranged it so that besiegers would no longer be able to divert the river against the city by surrounding the inner city with three circuits of walls."[4]

In one of the most intriguing legends, Herodotus describes how Cyrus the Great successfully invaded Babylon in 539 B.C. by diverting the Euphrates River above the city into the desert and marching his troops into the city along the dry riverbed.

1. This chronology and that shown to the right come from H. Hatami and P. H. Gleick, *Chronology of Conflict over Water in the Legends, Myths, and History of the Ancient Middle East* (Oakland, Calif.: Pacific Institute for Studies in Development, Environment, and Security, June 1993).
2. S. Burstein, "The Babyloniaca of Berossus," in *Sources from the Ancient Near East* (Malibu, Calif.: Undena Publications, 1978).
3. L. L. Honor, *Sennacherib's Invasion of Palestine* (New York: Columbia University Press, 1926).
4. Burstein, note 2 above.

number of Syrian dams on the Yarmuk River. These dams were built to allow Syria to make use of the Yarmuk's flow, which would otherwise be available for use in Israel or Jordan.

Shared Groundwater Aquifers

A significant fraction of Israel's water comes from shared groundwater aquifers that underlie both the West Bank and the Gaza Strip (see Figure 2 on page 12). By some estimates, 40 percent of the groundwater that Israel uses—and more than one-third of its sustainable annual water yield—comes from the occupied territories.[8] Though no accurate studies have been published, it is estimated that the long-term potential yield of the West Bank aquifers is just less than 700 million m^3/y, of which about 180 million is brackish water.[9] These aquifers are replenished almost entirely by rainfall on the West Bank. The largest of the aquifers, the Western (called the Yarkon-Taninim aquifer in Israel), flows west toward the Mediterranean Sea. This groundwater supply is tapped extensively by Is-

A PARTIAL CHRONOLOGY OF CONFLICT OVER WATER IN THE ANCIENT MIDEAST

3000 B.C.—The Flood

An ancient Sumerian legend recounts the deeds of the diety Ea, who punishes humanity for its sins by inflicting the Earth with a six-day storm. The Sumerian myth parallels the Biblical account of Noah and the deluge, although some details differ.

2500 B.C.—Lagash-Umma Border Dispute

The dispute over the "Gu'edena" (edge of paradise) region begins. Urlama, King of Lagash from 2450 to 2400 B.C., diverts water from this region to boundary canals, drying up boundary ditches to deprive Umma of water. His son Il cuts off the water supply to Girsu, a city in Umma.

1790 B.C.—Code of Hammurabi for the State of Sumer

Hammurabi lists several laws pertaining to irrigation that provide for possible negligence of irrigation systems and water theft.

1720–1684 B.C.—Abi-Eshuh v. Iluma-Ilum

A grandson of Hammurabi, Abish or Abi-Eshuh, dams the Tigris to prevent the retreat of rebels led by Iluma-Ilum, who declared independence of Babylon. This failed attempt marks the decline of the Sumerians who had reached their apex under Hammurabi.

1200 B.C.—Moses and the Parting of the Red Sea

When Moses and the retreating Jews find themselves trapped between the pharaoh's army and the Red Sea, Moses miraculously parts the waters of the Red Sea, allowing his followers to escape. The waters close behind them and cut off the Egyptians.

720–705 B.C.—Sargon II Destroys Armenian Waterworks

After a successful campaign against the Haldians of Armenia, Sargon II of Assyria destroys their intricate irrigation network and floods their land.

705–682 B.C.—Sennacherib and the Fall of Babylon

In quelling rebellious Assyrians in 695 B.C., Sennacherib razes Babylon and diverts one of the principal irrigation canals so that its waters wash over the ruins.

Sennacherib and Hezekiah

As recounted in Chronicles 32:3, Hezekiah digs a well outside the walls of Jerusalem and uses a conduit to bring in water. Preparing for a possible siege by Sennacherib, he cuts off water supplies outside of the city walls, and Jerusalem survives the attack.

681–669 B.C.—Esarhaddon and the Siege of Tyre

Esarhaddon, an Assyrian, refers to an earlier period when gods, angered by insolent mortals, create a destructive flood. According to inscriptions recorded during his reign, Esarhaddon besieges Tyre, cutting off food and water.

669–626 B.C.—Assurbanipal, Siege of Tyre, Drying of Wells

Assurbanipal's inscriptions also refer to a siege against Tyre, although scholars attribute it to Esarhaddon. In campaigns against both Arabia and Elam in 645 B.C., Assurbanipal, son of Esarhaddon, dries up wells to deprive Elamite troops. He also guards wells from Arabian fugitives in an earlier Arabian war. On his return from victorious battle against Elam, Assurbanipal floods the city of Sapibel, an ally of Elam. According to inscriptions, he dams the Ulai River with the bodies of dead Elamite soldiers and deprives dead Elamite kings of their food and water offerings.

612 B.C.—Fall of Ninevah in Assyria and the Khosr River

A coalition of Egyptian, Median (Persian), and Babylonian forces attacks and destroys Ninevah, the capital of Assyria. Nebuchadnezzar's father, Nebopolassar, leads the Babylonians. The converging armies divert the Khosr River to create a flood, which allows them to elevate their siege engines on rafts.

605–562 B.C.—Nebuchadnezzar Uses Water to Defend Babylon

Nebuchadnezzar builds immense walls around Babylon, using the Euphrates and canals as defensive moats surrounding the inner castle.

558–528 B.C.—Cyrus the Great Digs 360 Canals

On his way from Sardis to defeat Nabonidus at Babylon, Cyrus faces a powerful tributary of the Tigris, probably the Diyalah. According to Herodotus's account, the river drowns his royal white horse and presents a formidable obstacle to his march. Cyrus, angered by the "insolence" of the river, halts his army and orders them to cut 360 canals to divert the river's flow. Other historians argue that Cyrus needed the water to maintain his troops on their southward journey, while another asserts that the construction was an attempt to win the confidence of the locals.

539 B.C.—Cyrus the Great Invades Babylon

According to Herodotus, Cyrus invades Babylon by diverting the Euphrates above the city and marching troops along the dry riverbed. This popular account describes a midnight attack that coincided with a Babylonian feast.

355–323 B.C.—Alexander the Great Destroys Persian Dams

Returning from the razing of Persepolis, Alexander proceeds to India. After the Indian campaigns, he heads back to Babylon via the Persian Gulf and Tigris, where he tears down defensive weirs that the Persians had constructed along the river. Arrian describes Alexander's disdain for the Persians' attempt to block navigation, which he saw as "unbecoming to men who are victorious in battle."

rael, primarily from within the boundaries of pre-1967 Israel. The other aquifers also are largely controlled and heavily used by Israel, both within Israel proper and in the settlements in the occupied territories.

The control of the water from these aquifers is one of the major sources of tension between the Palestinians and the Israelis. Among the unresolved questions are the extent to which these three aquifers are used, disputes over their control and management, uncertainties about the effects of large withdrawals on water quality, and arguments over the yields that can be provided safely.

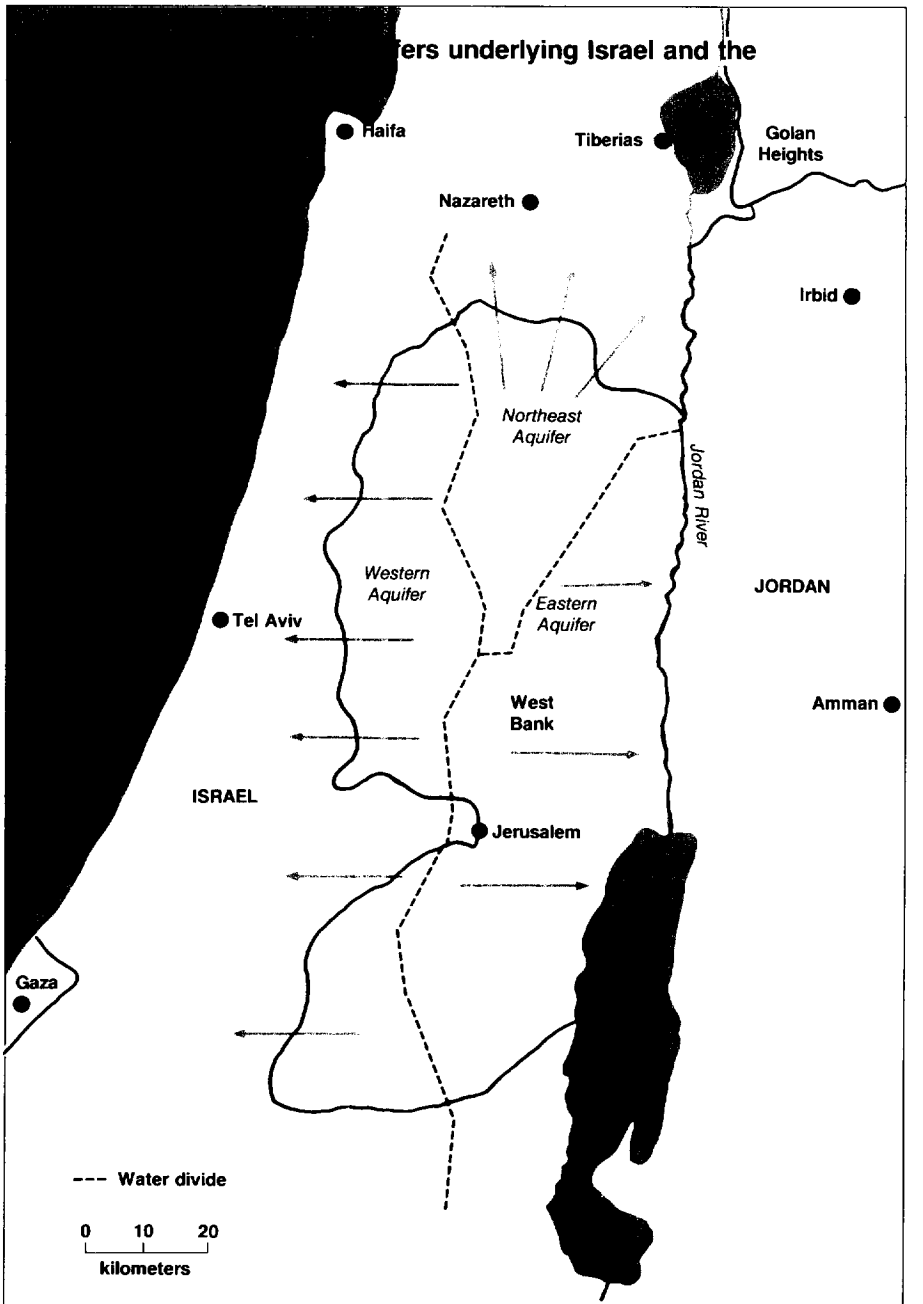
The Tigris and Euphrates

The Tigris and Euphrates Rivers are among the largest in the region. Both rivers originate in the mountains of Turkey, flow south through Syria and Iraq, and drain through the Shatt Al-Arab waterway into the Persian Gulf (see Figure 3 on page 14). Several tributaries of the Tigris drain the Zagros Mountains between Iran and Iraq, and 15 percent of the Euphrates basin is in Saudi Arabia, though essentially none of its flow is generated there. Average annual runoff in these two rivers exceeds 80,000 million cubic meters, of which about 33,000 million are generated in the Euphrates and 47,000 in the Tigris.[10] Flows in both rivers are extremely variable. Minimum flows of the Euphrates have been reported as low as 180 cubic meters per second, while maximum flows as high as 5,200 cubic meters per second have occurred.[11] Half of the annual runoff of the Euphrates is generated during the brief spring (April and May) snowmelt, and runoff in dry years has amounted to as little as 30 percent of the annual average flow.

Ninety percent of the water in the Euphrates River originates in Turkey, though Turkey has only 28 percent of the area of the Euphrates basin. Almost all of the remainder of the flow originates in Syria. Turkey, Syria, and Iraq have large and rapidly growing populations (see Table 2), and all three countries have ambitious plans to increase their withdrawals of water for irrigation.

Although Syria has other water resources, these are largely tapped or, like the Yarmuk, contested, and the Euphrates is the only major river crossing its territory with reliable annual flows. Iraq is the most heavily dependent upon the Euphrates at present, but it has an alternative source of water in the Tigris system, which currently is lightly used.

Recent developments on the Euphrates in southern Turkey, particularly the completion of the massive Ataturk Dam, are viewed by the other basin nations with mixed feelings.



SOURCE: Redrawn from a map in H. A. Amery, "Cooperative Water Management in the Middle East," in *Proceedings of the International Symposium on Water Resources in the Middle East: Policy and Institutional Aspects* (Urbana, Ill., 1993), 59–68.

Such developments could help to reduce the extreme variations in flow and ensure predictable supplies in downstream countries, but they could lead to greater upstream withdrawals and a reduction in overall flows to Syria by as much as 40 percent and to Iraq by up to 80 percent, especially during dry years.[12] No formal agreement has yet been reached on minimum releases either by Turkey to Syria or by Syria to Iraq. Iraq believes that full development of the ambitious Turkish Southeast Anatolia Development Project (of which the Ataturk Dam is a part) and the more modest irrigation plans in Syria would deprive Iraq of sufficient water for its own irrigation plans.

Water quantity is not the only concern facing countries in the Euphrates basin. The quality of Euphrates water is being adversely affected by withdrawals and irrigation return flows. A large portion of the water entering Iraq already consists of return flows containing high concentrations of both agricultural chemicals and salts. As a result, salinization of cropland and loss of agricultural productivity are growing concerns.

For 30 years, negotiations over the Euphrates among Turkey, Syria, and Iraq have produced no lasting agreement, in part because the three countries have long been at odds with each other. For example, Syria and Iraq have opposed Turkey over its membership in NATO, and Syria and Turkey opposed Iraqi military actions in the 1970s. In the 1980s, Turkey and Iraq tended to band together against Syrian military aggression, and Turkey and Syria sided with the allied forces against Iraq during the Persian Gulf War in the early 1990s.

Water-related disputes arose in the basin in the 1960s after both Turkey and Syria began to draw up plans for large-scale irrigation withdrawals. In 1965, tripartite talks were held in which each of the three countries put forth demands that, together, exceeded the natural yield of the river. Also in the mid-1960s, Syria and Iraq began bilateral negotiations over formal water allocations, but, by the end of the decade, no formal agreement had been reached. In the 1970s, an agreement was reached, though never signed, that allocated portions of overall flow to both Syria and Iraq. In the mid-1970s, dams at Keban, Turkey, and Tabqa, Syria, were completed, and their reservoirs had begun to fill, reducing flows to Iraq.[13]

In 1974, Iraq alleged that the flow of water in the Euphrates had been reduced by the Syrian dam, threatened to bomb it, and massed troops along the border. In spring of 1975, tensions between Iraq and Syria peaked as Iraq claimed that Syria was intentionally reducing flows to intolerably low levels. During April and May, the two countries traded hostile statements in which Iraq threatened to take any action necessary to ensure the Euphrates's flow. Iraq also issued a formal protest to the Arab League that Syria was intentionally depriving it of its rightful share. On 13 May, Syria closed its airspace to all Iraqi aircraft, suspended Syrian flights to Baghdad, and reportedly transferred troops from its front with Israel to the Iraqi border. The angry confrontation ended just short of military action after mediation by Saudi Arabia. Syria reportedly agreed to release additional water to Iraq, from "its own share" as a goodwill gesture.[14]

In the last few years, Turkey's new water supply projects have been the focus of new political concerns in the basin. Tensions arose in January 1990 when Turkey completed construction of the Ataturk Dam and closed the dam to begin filling the reservoir, interrupting the flow of the Euphrates for a month. Despite advance warning from Turkey of the temporary cutoff, Syria and Iraq both protested that Turkey now had a water weapon that could be used against them. Indeed, in October 1989, Turkish Prime Minister Turgut Ozal had threatened to restrict water flow to Syria to force it to withdraw support for Kurdish rebels operating in southern Turkey.[15]

TABLE 1
INTERNATIONAL RIVER BASINS IN THE MIDDLE EAST

River basin	Total area of basin (square kilometers)	Countries in basin	Area (square kilometers)	Percentage of total area
Tigris	378,850	Iran	220,000	58
		Iraq	110,000	29
		Turkey	48,000	13
		Syria	850	<1
Euphrates	444,000	Iraq	177,000	40
		Turkey	125,000	28
		Syria	76,000	17
		Saudi Arabia	66,000	15
Orontes	13,300	Syria	9,700	73
		Turkey	2,000	15
		Lebanon	1,600	12
Jordan	19,850	Jordan	7,650	39
		Syria	7,150	36
		Israel	4,100	21
		Lebanon	950	5
Nile	3,031,000	Sudan	1,900,000	63
		Ethiopia	368,000	12
		Egypt	300,000	10
		Uganda	233,000	8
		Tanzania	116,000	4
		Kenya	55,000	2
		Zaire	23,000	1
		Rwanda	21,500	1
		Burundi	14,500	<1

Thus, Turkish politicians' claims that the shutoff to fill the Ataturk's reservoir was entirely for technical, not political, reasons failed to appease Syrian and Iraqi officials, who argued that Turkey had already used its power over the headwaters of the Euphrates for political goals and could do so again.[16]

The ability of Turkey to shut off the flow of the Euphrates, even temporarily, was noted by political and military strategists at the beginning of the Persian Gulf conflict.[17] In the early days of the war, there were behind-the-scenes discussions at the United Nations about using Turkish dams on the Euphrates River to cut off water to Iraq in response to its invasion of Kuwait. Although no such action was taken, the threat of the "water weapon" was again made clear.[18]

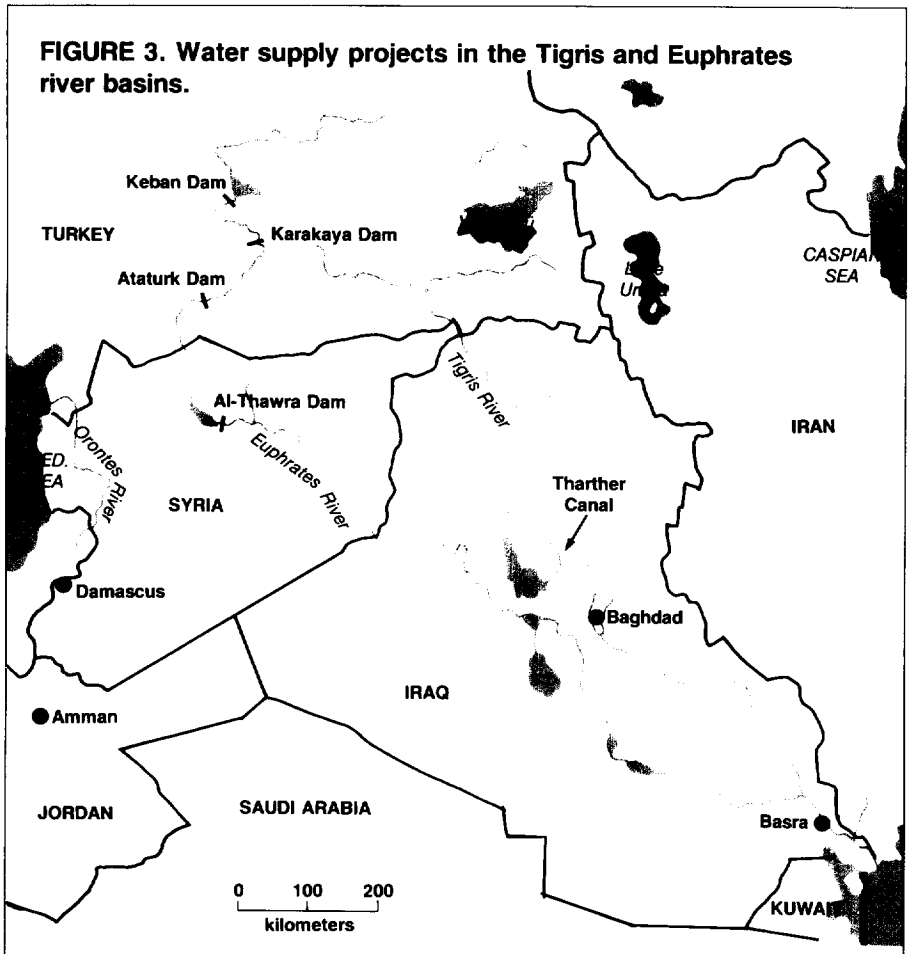
The Nile River

The Nile River, the longest in the world, flows more than 6,800 kilometers from the highlands of central Africa and Ethiopia through nine nations to the Mediterranean. The nations that share the Nile are Egypt, Sudan, Ethiopia, Kenya, Tanzania, Zaire, Uganda, Rwanda, and Burundi, and the watershed covers nearly 10 percent of the African continent (see Figure 4 on page 36). Two major tributaries form the Nile: the White Nile, which starts in central Africa's Lake Plateau region, and the Blue Nile, which originates in the highlands of Ethiopia. More than 80 percent of the Nile's flow comes from the torrential seasonal flows of the Blue Nile. Like the other rivers in the Middle East, the Nile exhibits substantial hydrologic variability. Although the large Aswan Dam has buffered Egypt from some of this variability, a recent 10-year drought in the region has shown the limits of even major dams, and the Aswan has had a wide range of other impacts.[19]

The Nile River is also a shared water resource of tremendous regional importance, particularly for agriculture in Egypt and Sudan. Ninety-seven percent of Egypt's water comes from the Nile River, and more than 95 percent of the Nile's runoff originates outside of Egypt in the other eight nations of the basin. The Nile valley has sustained civilizations for more than 5 millennia, but historical evidence suggests that the populations of ancient Egypt never exceeded 1.5 million to 2.5 million people.[20] Today, Egypt struggles to sustain a population rapidly approaching 60 million on the same limited base of natural resources. And Egypt's population grows by another million people every nine months.

A treaty was signed in 1959 allocating the water of the Nile between Egypt and Sudan.[21] Although this treaty has effectively reduced the risk of conflict between the two countries over water, none of the other seven nations of the basin is party to it, and several have expressed a desire to increase their use of Nile River water. Additional use of water by these other nations of the Nile basin, particularly by Ethiopia, could reduce water available to the downstream nations and greatly increase tensions over water. Concern over the security of Egypt's water supplies led President Anwar Sadat to say in 1979, "The only matter that could take Egypt to war again is water."[22] More recently, Egypt's foreign minister, Boutros Boutros-Ghali, now Secretary-General of the United Nations, was quoted as saying "The next war in our region will be over the waters of the Nile, not politics."[23] Although these state-

FIGURE 3. Water supply projects in the Tigris and Euphrates river basins.



SOURCES: Redrawn from maps of J. Waterbury, "Dynamics of Basin-Wide Cooperation in the Utilization of the Euphrates" (paper prepared for the conference "The Economic Development of Syria: Problems, Progress, and Prospects," Damascus, 6–7 January 1990); and General Staff Map Section, Director General of Military Survey, Ministry of Defence, United Kingdom, 1991.

TABLE 2
MIDDLE EAST POPULATION ESTIMATES AND PROJECTIONS

Country	1990	2000 (millions)	2025	Annual percentage rate of increase in 1990
West Bank[a]	0.90	1.12	2.37	3.40
Gaza Strip	0.62	0.76	1.23	1.98
Israel	4.66	6.34	8.15	1.67
Jordan	3.10	4.00	8.50	3.41
Lebanon	2.74	3.31	4.48	2.00
Syria	12.36	17.55	35.25	3.58
Saudi Arabia	14.87	20.67	40.43	3.28
Turkey	55.99	68.17	92.88	2.05
Iraq	18.08	24.78	46.26	3.21
Iran	58.27	77.93	144.63	2.71

[a]Population figures are for 1991 and 2020 instead of 1990 and 2025.

Note: Growth rates in Jordan, Israel, the West Bank, and the Gaza Strip depend largely on immigration rates and thus are difficult to project.

SOURCES: United Nations, *World Population Prospects: The 1992 Revision, Annex Tables* (New York, 1993); and J. D. Priscoli and R. Brumbaugh, *Water in the Sand* (Washington, D.C.: U.S. Army Corps of Engineers, 1991).

ments partly reflect political rhetoric, they indicate the importance of the Nile to Egypt.

The Litani and Orontes Rivers

Two other important rivers flow through parts of the Middle East: the Orontes and the Litani. The Litani River is the only important river contained entirely within one country, Lebanon, and one of the few that have not been tapped to the limit. The Litani rises in the mountains surrounding the Bekaa Valley and flows 145 kilometers south and west into the Mediterranean Sea. Average annual flow in the basin is a little more than 900 million cubic meters, and two-thirds of this flow occurs between January and April.[24] Only about half of the average flow is currently used, primarily for irrigation. The waters of the Litani River also provide approximately 40 percent of Lebanon's total electricity supply and are of very high quality, although the effect of current agricultural water use in the lower Litani basin has not been documented.

The Orontes originates in central Lebanon and flows north through Syria and Turkey before emptying into the Mediterranean Sea. Three-quarters of the basin is in Syria, and the major use of Orontes River water is for irrigation in Syria's Ghab Valley. Although there may be some surplus water in the basin, additional developments in Syria and contamination of the water by sewage and industrial effluents limit any significant shared use of Orontes water by Turkey.

The Potential for Water Wars

The Persian Gulf War underscored the many connections between water and conflict. During this war, water and water supply systems were targets of attack, shared water supplies were used as instruments of politics, and water was considered a potential tool of warfare. The dams, desalination plants, and water conveyance systems of both sides were targeted for destruction. Most of Kuwait's extensive desalination capacity was destroyed by the retreating Iraqis. Oil spilled into the gulf threatened to contaminate desalination plants throughout the region. And the intentional destruction of Baghdad's modern water supply and sanitation system was so complete that the Iraqis are still suffering severe problems as they rebuild them.[25]

Although water resources are only one source of tension in the Middle East, pressures over water are likely to grow in the future because of demographic trends, changing patterns of water use, and possible changes in supply caused by global climate change—the greenhouse effect. Few of the countries in the region believe that they have adequate water for their current populations; almost none believes that it can continue to provide adequate water as its population continues to grow and as industry and agriculture increase their demands for freshwater.

Population Growth

In some of the most water-short parts of the Middle East, most notably the Jordan and Euphrates river basins, populations are expected to grow extremely rapidly (see Table 2). At the same time, new demands for water are putting pressure on existing supplies. In Israel and Jordan, projected population growth could require the severe restriction or complete elimination of irrigated agriculture over the next several decades just to free up sufficient water to provide a reasonable minimum amount to their populations.

For example, the United Nations' medium projections show the population of Israel and the Gaza Strip reaching 10 million by 2025, not including the Palestinians presently included by the United Nations in Jordan's population.[26] Simply supplying this population with a minimum annual water requirement of 150 cubic meters per person for drinking, sanitation, and all commercial and industrial activities would require 1,500 million m^3/y, which is approximately equal to Israel's entire long-term reliable supply. This level of use would leave only recycled wastewater for the agricultural sector and so would almost completely eliminate irrigated agriculture.

Table 3 on page 37 shows how the per-capita availability of water in the countries of the Middle East and parts of the Persian Gulf is likely to decrease given the expected population growth between now and 2025. Most hydrologists believe that having less than 500 cubic meters available per person per year significantly lim-

(continued on page 35)

its the options available to a society.[27] Many countries in the region already fall into this category, and more will in the future as populations grow.

Climate Change

All debates about regional water supplies assume that natural water availability in the future will not change and that flows will be subject only to natural variations. In fact, this assumption may no longer be true because of possible changes in the global climate.[28] Global climate change could affect water availability in many ways, though the precise nature of such changes is still obscure. Climate change could either increase or decrease overall water availability in different times and in different places.[29] Estimates of changes in temperature and precipitation patterns in the Middle East are mixed; average temperatures may rise between 3° and 6° C if the atmospheric concentration of carbon dioxide doubles, but precipitation projections show little consistency across different climate models, reflecting the difficulty of accurately modeling precipitation and the uncertainty about regional model results. Hydrologists expect higher temperatures to lead to substantial increases in evaporation in the region, which would decrease overall water supply and increase demand. Despite the limited ability of the current models to project future conditions accurately, even slight decreases in long-term water availability would place severe political strains on the region, as was seen from 1979 to 1988, when a drought reduced the average runoff in the Nile by only 10 percent. Although the nature of future climate changes in the region cannot be predicted with confidence, there are indications that long-term decreases in flow exceeding 10 percent are possible. Some preliminary modeling of the Nile basin suggests that Nile runoff would decrease by as much as 25 percent under some plausible conditions, and seasonal flows may experience even more significant changes.[30] Ironically, the possibility of increases in runoff during the snowmelt season raises the specter of increased frequency of severe flooding, as was experienced in Sudan in 1988.[31]

Future climate changes effectively make obsolete all old assumptions about the behavior of water supply. Perhaps the greatest certainty about future climate change is that the future will not look like the recent past. Changes are certainly coming, and, by the turn of the century, many of these changes may already be apparent. The challenge is to identify those cases in which conflicts are likely to be exacerbated and to reduce the probability and consequences of those conflicts.


U.S. AGENCY FOR INTERNATIONAL DEVELOPMENT

As water demand in northeast Africa increases with population growth, Egyptian farmers along the Nile may find irrigation water in short supply.

Reducing Conflicts over Water

There is no single solution to the Middle East's water problems, and, ultimately, a combination of efforts and innovative ideas must be applied. Formal political agreements will have to be negotiated to apportion and manage the shared surface- and groundwater in the region, particularly in the Jordan and Euphrates river basins and the occupied territories. Unless all of the people who depend on the resources concerned are included in these agreements, conflicts will remain. In particular, definitions of *equitable utilization* of the existing water resources must be negotiated and applied.[32] Difficult decisions must also be made to prioritize water use within each country. Israel, like California and many other parts of the world, is wrestling with the conflicts between urban and rural water demands and between the agricultural and domestic sectors. Jordan is trying to improve its water-use efficiency so that it, like Israel, can make better use of its limited supplies. And all parties are exploring ways of increasing supply within serious economic and environmental constraints. Sharing of expertise, opening access to hydrologic data, and exploring joint water conservation and supply projects offer the best opportunities for reducing the risk of future tensions over water in the Middle East.

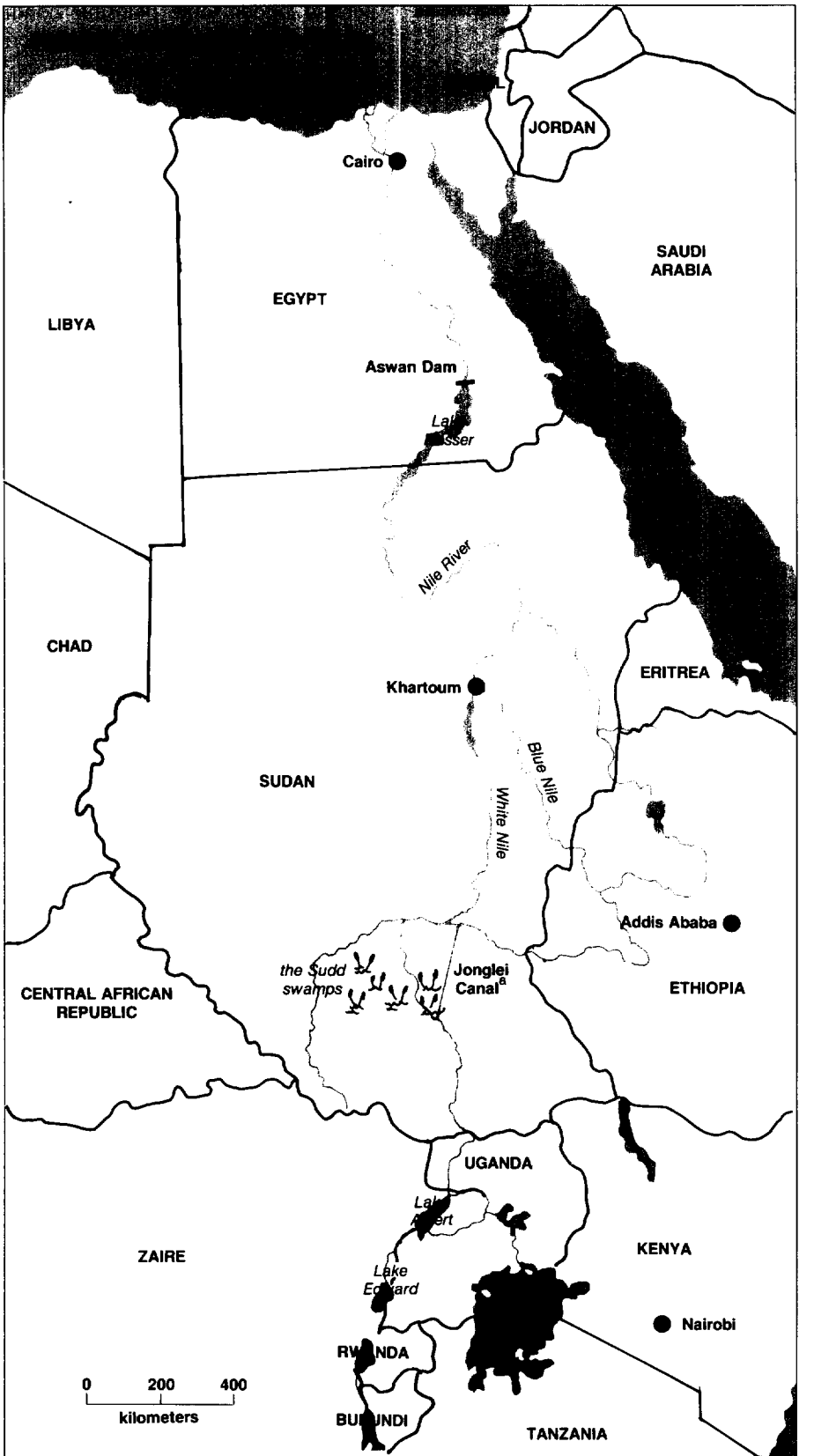
Water Rights and Control

The conflicts over water in the Middle East are not only about limited water availability; they also arise over the control of existing resources. In the Jordan basin, control over

shared groundwater resources underlying the West Bank and the Gaza Strip are at the heart of the tension between Israelis and Palestinians. In 1967, Israel issued Military Order 92, which prohibits the drilling of new wells without permission from the military authorities, fixes quotas for pumping from existing wells, and expropriates wells in all occupied lands.[33] The Palestinians claim that these restrictions have, effectively, frozen Palestinian use of water in the occupied territories, resulted in insufficient water for Palestinian urban and industrial use, and stopped new agricultural development. At the same time, Israel has allowed the development of water wells for Jewish settlements in the occupied areas. One outcome of this situation is a gross discrepancy in per-capita water use by Israelis and Palestinians in the occupied territories. The perception that much of the Israeli water goes to nonessential uses, such as irrigation of lawns and the filling of swimming pools, has not helped the problem.[34]

This difference has played a direct role in framing the ongoing peace talks. Although many Israelis argue that efforts should focus on enlarging the "pie" so that existing uses can be maintained, Palestinians insist that a discussion of reallocation of water rights and control over the existing supply must precede any major efforts to enhance total availability. These distinct viewpoints have led to two distinct tracks in the peace talks: a discussion of water rights in the bilateral talks and a discussion of ways to enhance supply in the multilateral water talks (see the box on page 8). Unless this disagreement is dealt with directly, the chances of resolving other water problems in the region are limited.

Once the issue of water rights is resolved, new options open up for reallocating existing water, including water marketing and sales or leasing of water rights. Recent experience in California with water marketing and "banking" suggests that short-term or long-term sales of water can be ac-



[a]Construction of the canal has been stopped.

SOURCE: Redrawn from a map of the General Staff Map Section, Director General of Military Survey, Ministry of Defence, United Kingdom, 1991.

complished if appropriate institutions and incentives are developed. Under the right circumstances, those in possession of water rights may have an incentive to shift that water to more valued uses in return for economic benefits. Such transfers must be voluntary and equitable, but experience in the western United States suggests a variety of approaches that could be appropriate in the Middle East.[35] For example, the California Water Bank, created in 1991 during a long-term drought, bought nearly 1,000 million cubic meters of water from farmers at a price of $0.10 per cubic meter. This water was then sold to urban centers, and a small portion was set aside to aid threatened ecosystems.

The creation of a comparable water bank or market between the Palestinians and the Israelis could permit the Palestinians to sell or lease any unused West Bank water. If Israel were to "buy" groundwater from West Bank aquifers at $0.06 per cubic meter (about what agricultural users currently pay), the annual payment per 100 million cubic meters would be only $6 million. If the price were as high as $0.30 per cubic meter (about what urban users currently pay), this volume of water would cost about $30 million per year. At this higher price, there is a strong incentive to find alternative sources of supply or to increase investment in water-saving technologies. Creating this sort of market for water transfers would require some innovative institutional arrangements, but it could also offer benefits to all users in the region.

Supplying a "Minimum Water Requirement"

Another new proposal that may begin to address the problem of water rights and the equitable distribution and utilization of existing water is to establish a minimum water requirement for the population in a region.[36] Such a minimum would be guaranteed to all residents and would provide for the minimum basic human needs of drinking water, sanitation, and domestic use and for moderate urban industrial and commercial uses. Although no minimum water requirement has been formally defined, present urban water uses suggest that an appropriate level may be between 75 and 150 m^3/y per person. Mechanisms must be developed to permit transfers from regions with water in excess of these amounts to regions without this minimum and to allocate the remaining water resources after the minimum is supplied. Supplying this minimum should be a higher priority than expanding overall supplies because it effectively defines an equitable water right.

Increased Efficiency of Use

Increasing the efficiency of water use in all the countries of the region may be the most economical and least controversial of all proposals. Even modest increases in the efficiency of agricultural water use and decreases in consumptive use[37] could dramatically increase overall availability in other sectors. A 10-percent reduction in agricultural water use in Israel, for example, would double the water available for urban users. Israel has pioneered many improvements in agricultural irrigation efficiency and the recycling and reuse of wastewater for certain uses, but, despite the fact that Israel is already one of the most water-efficient countries in the world, continued improvements in the efficiency with which water is used are possible. Jordan is now implementing similar measures to cope with its increasing water problems. In Jordan, the on-farm efficiency of water use is still low (only about 40 percent is productively used) and evaporation rates and seepage losses from open irrigation canals in the Jordan Valley are high. High subsidies for agricultural water by all of the countries in the region also contribute to continued wasteful, inefficient use.[38]

A major area for increasing the efficiency of water use is wastewater reuse and water reclamation. In Israel, substantial advances have been made in water reclamation and reuse. Tel Aviv, for example, is reusing more than one-third of its wastewater for purposes other than drinking water.[39] Overall, approximately 5 percent of Israel's entire water use is recycled wastewater, and that percentage is increasing. By 2000, the Jordan Water Authority expects that one-quarter of east Jordan Valley irrigation water will come from recycled sewage water.[40] Although this use of water will be limited by religious, social, health, and environmental concerns, the technology exists to clean and recycle wastewater adequately for many purposes.

TABLE 3
PER-CAPITA WATER AVAILABILITY IN 1990 AND 2025

Country	1990 (cubic meters per person per year)	2025 (cubic meters per person per year)
Kuwait	75	57
Saudi Arabia	306	113
United Arab Emirates	308	176
Jordan	327	121
Yemen	445	152
Israel	461	264
Qatar	1,171	684
Oman	1,266	410
Lebanon	1,818	1,113
Iran	2,025	816
Syria	2,914	1,021
Iraq	5,531	2,162

SOURCE: P. H. Gleick, *Water in Crisis: A Guide to the World's Fresh Water Resources* (New York: Oxford University Press, 1993).

New Supplies

The traditional reaction to resource pressures is to focus on how to increase supplies, and this is true in the Middle East as well. There are two principal ways to increase supplies: bring in outside sources of water and capture unused portions of the current supply by building reservoirs to store flows during wet periods for use during dry periods. Many ideas for developing new sources in the Middle East have been proposed, including building desalination plants to make freshwater out of seawater or brackish water; constructing enormous pipelines to divert underused rivers in Turkey or

Pakistan to the parched regions of the Middle East and the Persian Gulf; tankering or towing enormous bags of freshwater to coastal areas; laying aqueducts from the Mediterranean Sea or the Red Sea to the Dead Sea to generate electricity and desalinate saltwater; and building new reservoirs on major rivers to increase storage for dry periods.

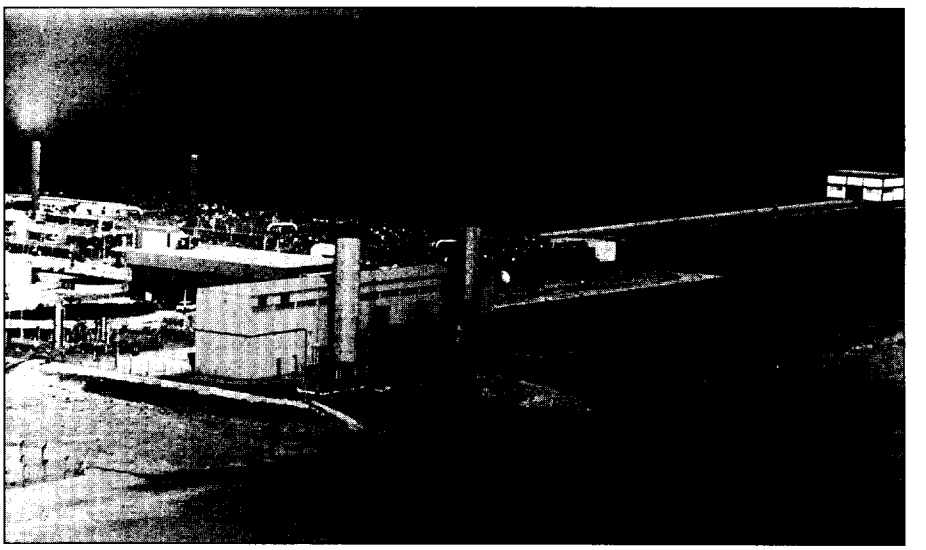
All of these proposals are controversial, and all have uncertain economic and environmental costs. In addition, political disputes over who would control the sources of some of these options make the construction of new facilities extremely unlikely in the absence of a lasting political settlement. On the other hand, some new sources of supply may eventually be developed as the economic value of water rises and as demands grow:

• *Desalination*—Ninety-seven percent of the water on the planet is too salty to drink or to grow crops. This had led to great interest in devising ways of removing salt from water in the hope of providing unlimited supplies of freshwater. Indeed, by the beginning of 1990, there were more than 7,500 facilities worldwide producing more than 13.2 million cubic meters of freshwater per day. More than half of this desalination capacity is in the Persian Gulf region, where inexpensive fossil fuels provide the energy necessary to run the plants[41] (see Table 4 on page 39). For other regions, however, the high energy cost of desalination continues to make unlimited freshwater supplies an elusive goal. In the long run, the use of desalination will be limited by the amount and cost of the energy required to purify saltwater. Unless unanticipated major technical advances reduce overall energy requirements or the price of energy drops substantially, large-scale desalination will always be limited to extremely water-poor and energy-rich regions.

• *Peace Pipelines*—Various proposals have been presented for pipelines to transfer water from Turkey to the Middle East and the countries around the Persian Gulf. Nicknamed the "Peace Pipeline," such a project would take water from the Seyhan and Ceyhan Rivers in southern Turkey as far south as Jidda and Mecca in Saudi Arabia and as far east as Sharjah in the United Arab Emirates. Along the way, water could be delivered to Damascus, Amman, Kuwait, and Israel. One version of the Peace Pipeline would deliver more than 1,000 million cubic meters of water per year, but little real progress has come of the various proposals. In part, the Arabs, particularly the Saudis, and the Israelis fear the political dominance of Turkey or the possible interference of other states across which the pipeline would pass.[42] The recent Turkish threats to cut off Euphrates River water to Syria have not helped to lessen this perception. Variants on the longer pipeline, such as a shorter version extending only as far as Amman, have also been proposed. Such variants may have fewer political constraints, but many environmental, economic, and political problems remain to be resolved before such a major transnational construction project could begin.

• *Other Out-of-Basin Transfers*—There have been many other proposals to transfer water to the Middle East from basins where surplus water may be available. Such transfers could be accomplished via pipelines, aqueducts, tankers, floating bags, and even towing icebergs. Among the projects proposed have been pipelines from Baluchistan across the gulf to the United Arab Emirates, from the Euphrates in Iraq to Jordan, and from the Nile through El Arish to the Gaza and Negev to alleviate the severe water crisis in the Gaza Strip.[43] Each of these projects depends on the long-term availability of surplus water and the political, economic, and environmental feasibility of transferring that water. Similarly, it has been proposed that Israel and Jordan purchase water from the Litani River in Lebanon, build a short pipeline and set of pumping plants, and move water to northern Israel, the West Bank, and Jordan. While Litani River water is used for hydroelectricity, some surplus is currently thought to be available if the economic and political price is right.[44]

Moving water by tankers or by towing "trains" of bags filled with freshwater is also being explored for supplying coastal areas. For the Gaza Strip, where overpumping of limited groundwater supplies is leading to saltwater intrusion, such alternatives may prove feasible, though technical and political obstacles still must be removed.


SAUDI ARAMCO PHOTO

This desalination plant in al-Khobar, Saudi Arabia, produces more than 100 million gallons of freshwater each day.

• *Med-Dead or Red-Dead Canal*—Another alternative that has been suggested in various forms is to bring large quantities of seawater from the Mediterranean Sea or the Red Sea to the Dead Sea, which lies well below sea level. The large elevation drop would permit the generation of hydroelectricity, which in turn could be used to satisfy the energy requirements of a desalination plant. The freshwater provided by such a system could be allocated to Israel, the occupied territories, or western Jordan, where it would reduce pressures on the limited water supplies in those regions. Brine from the desalination process or additional seawater could be diverted into the Dead Sea to help raise its level, which has dropped nearly 20 meters over the last several decades because of the use of the Jordan River--its only inflow. Many different schemes and locations have been presented for such canals, and more work is needed to explore the best routes, the best allocation of water, and the many complicated environmental and economic uncertainties posed by such projects.

Politics and International Law

International water law and institutions have important roles to play despite the fact that no satisfactory water law has been developed that is acceptable to all nations. Developing such agreements is difficult because of the many intricacies of international politics, national practices, and other complicating political and social factors. For nations sharing river basins, factors affecting the successful negotiation and implementation of international agreements include whether a nation is upstream, downstream, or sharing a river as a border; the relative military and economic strength of the nation; and the availability of other sources of water supply.

In the last few decades, however, international organizations have attempted to derive more general principles and new concepts governing shared freshwater resources. The International Law Association's Helsinki Rules of 1966 (since modified) and the work of the International Law Commission of the United Nations are among the most important examples. In 1991, the International Law Commission completed the drafting and provisional adoption of 32 articles on the law of the Non-Navigational Uses of International Watercourses.[45] Among the general principles set forth are those of equitable utilization, the obligation not to cause harm to other riparian nations, and the obligation to exchange hydrologic and other relevant data and information on a regular basis. Questions remain, however, about the principles' relative importance and means of enforcement.[46] In particular, defining *equitable utilization* of a shared water supply remains one of the most important and difficult problems facing many nations.

Until now, individual water treaties covering river basins have been more effective, albeit on a far more limited regional basis, than the broader principles described by the International Law Commission. International treaties concerning shared freshwater resources extend back centuries, and there are hundreds of international river treaties covering everything from navigation to water quality to water rights allocations. For example, freedom of navigation was granted to a monastery in Europe in the year 805, and a bilateral treaty on the Weser River, which today flows through Germany into the North Sea, was signed in 1221.[47] Such treaties have helped reduce the risk of water conflicts in many areas, but some of them are beginning to fail as changing levels of development alter the water needs of regions and nations. The 1959 treaty on the Nile River and some limited bilateral agreements on the Euphrates between Iraq and Syria and between Iraq and Turkey, for example, are now under pressure because of changes in the political and resource situations in the regions.

To make both regional treaties and broader international agreements over water more flexible, detailed mechanisms for conflict resolution and negotiations must be developed, basic hydrologic data must be acquired and shared with all parties, flexible rather than fixed water allocations are needed, and strategies for sharing shortages and apportioning responsibilities for floods must be developed before shortages become an important factor. For example, both the 1944 Colorado River treaty between the United

TABLE 4
DESALINATION CAPACITY IN THE MIDDLE EAST AS OF 1990

Country	Capacity (cubic meters per day)	Percentage of global capacity	Number of plants
Saudi Arabia	3,568,868	26.8	1,417
Kuwait	1,390,238	10.5	133
United Arab Emirates	1,332,477	10.0	290
Libya	619,354	4.7	386
Iraq	323,925	2.4	198
Qatar	308,611	2.3	59
Bahrain	275,767	2.1	126
Iran	260,609	2.0	218
Oman	186,741	1.4	79
Israel	70,062	0.5	32
Egypt	67,728	0.5	110
Jordan	8,445	0.1	13
Syria	5,743	<0.1	12
Lebanon	4,691	<0.1	10

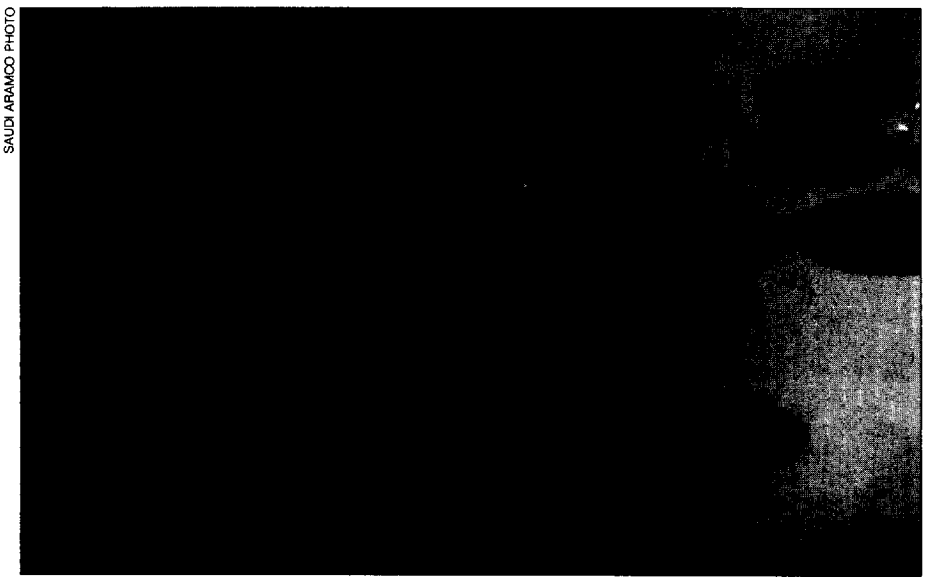
SOURCE: K. Wangnick, *1990 IDA Worldwide Desalting Plants Inventory*, report no. 11 (Gnarrenburg, Germany: Wangnick Consulting, 1990).

States and Mexico and the 1959 treaty on the Nile River between Egypt and Sudan allocate fixed quantities of water, which are based on assumptions about the total average flows of each river. However, mistaken estimates of average flows or future climate changes that could alter flows prove this type of allocation to be too rigid and prone to disputes. Proportional sharing agreements, if they include agreements for openly sharing all hydrologic data, can help to reduce the risk of conflicts over water, and modifications to these treaties should be undertaken by their signatories now, before such flow changes become evident.

Existing institutions appear sufficient to design and implement the kinds of conflict resolution mechanisms designed above, but some major improvements in them are needed. The United Nations has played an important role, through the International Law Commission, in developing guidelines and principles for internationally shared watercourses, but it should continue to press for the adoption and application of the principles in water-tense regions, such as the Jordan and Euphrates river basins. Similarly, bilateral or multilateral river treaties have been effective in the past, but they should consistently include all affected parties; establish joint management committees empowered to negotiate disputes; and be flexible enough to adapt to long-term changes in hydrologic conditions, such as those that may result from global climate change. Finally, disputes over shared groundwater resources are particularly important in the Middle East. However, international groundwater law and principles are poorly developed. Some recent progress has been made, but more attention should be given to this matter in the context of the Middle East.[48]

Toward Peace and Cooperation

For all of the countries of the Middle East, long-term sustainable economic development will depend in large part upon access to clean and dependable supplies of freshwater. Access to water, in turn, will depend upon regionwide comprehensive management of the shared major river and groundwater basins. Although new sources of water may eventually be developed, cooperation over the existing water resources is essential: Unless current water supplies are equitably and efficiently allocated and used, agreements to enlarge the overall pie will be stymied.


SAUDI ARAMCO PHOTO

Irrigation systems water agricultural fields that look like green polka dots out in the Arabian desert.

Enormous differences remain among the parties. Jordan still has a serious dispute with Syria over the damming of and withdrawals from the Yarmuk River; no formal agreements on water rights have been worked out between the Palestinians and Israelis; Turkey, Syria, and Iraq have no formal treaty allocating the waters of the Euphrates; and rapidly growing populations throughout the region are competing for an inadequate overall water supply, raising unanswered questions about the costs of alternative water sources.

At the broadest level, the Middle East needs a comprehensive framework for planning and managing shared water resources. If necessary, such a framework could be convened by third-party nations and institutions and include regional and national studies on water supply and demand, the development of standards for the collection and dissemination of data, the establishment of Jordan and Euphrates river basin authorities with representation from all of the people dependent on those water resources, and the identification of mechanisms for implementing joint projects. Some of the goals of a framework water convention would include identifying minimum water requirements and the equitable allocation of water; water-use efficiency capabilities and goals; means for shifting water use within and among sectors, such as through water "banks" or marketing; and objectives for providing new supplies. The opportunity for conflict over water in the Middle East is high, but peaceful, effective cooperation remains a goal worth striving for.

NOTES

1. For a review of the principle points in the ongoing debate, see J. T. Mathews, "Redefining Security," *Foreign Affairs* 68, no. 2 (1989): 162–77; P. H. Gleick, "Environment, Resources, and International Security and Politics," in E. Arnett, ed., *Science and International Security: Responding to a Changing World* (Washington, D.C.: American Association for the Advancement of Science, 1990), 501–23; T. Homer-Dixon, "On the Threshold: Environmental Changes as Causes of Acute Conflict," *International Security*

16, no. 2 (1991): 76-116; and P. H. Gleick, "Water and Conflict," *International Security* 18, no. 1 (1991): 79-112.

2. P. H. Gleick, ed., *Water in Crisis: A Guide to the World's Fresh Water Resources* (New York: Oxford University Press, 1993). See, also, M. Falkenmark, "Fresh Waters as a Factor in Strategic Policy and Action," in A. H. Westing, ed., *Global Resources and International Conflict* (New York: Oxford University Press, 1986), 85-113.

3. J. Kolars, "The Future of the Euphrates River" (paper presented at the International Workshop on Comprehensive Water Resources Management Policy, World Bank, Washington, D.C., 24-28 June 1991).

4. M. Shahin, *Hydrology of the Nile Basin*, Developments in Water Science, vol. 21 (Amsterdam: Elsevier Science Publishers, 1985); and J. F. Kolars and W. A. Mitchell, *The Euphrates River and the Southeast Anatolia Development Project* (Carbondale and Edwardsville, Ill.: Southern Illinois University Press, 1991).

5. T. Naff, "The Jordan Basin: Political, Economic, and Institutional Issues," in G. LeMoigne, ed., *Country Experiences with Water Resources Management*, World Bank Technical Paper no. 175 (Washington, D.C.: World Bank, 1992), 115-18.

6. S. C. Lonergan and D. B. Brooks, *The Economic, Ecological and Geopolitical Dimensions of Water in Israel* (Victoria, B.C.: University of Victoria, Centre for Sustainable Regional Development, 1992); and J. D. Priscoli and R. Brumbaugh, *Water in the Sand: A Survey of Middle East Water Issues* (Washington, D.C.: U.S. Army Corps of Engineers, 1991).

7. See, for example, T. Naff and R. C. Matson, eds., *Water in the Middle East: Conflict or Cooperation?* (Boulder, Colo.: Westview Press, 1984).

8. These data come from M. R. Lowi, "The Politics of Water Under Conditions of Scarcity and Conflict: The Jordan River and Riparian States" (Ph.D. diss., Department of Politics, Princeton University, Princeton, N.J., 1990), 342; and Naff, note 5 above. But the unwillingness of all parties in the region to share water resources data makes a complete analysis difficult.

9. H. I. Shuval, "Approaches to Finding an Equitable Solution to the Water Resources Problems Shared by Israel and the Palestinians over the Use of Mountain Aquifer," in G. Baskin, ed., *Israel/Palestine: Issues in Conflict, Issues for Cooperation*, vol. 1, no. 2 (Jerusalem: Israel/Palestine Center for Research and Information, 1992), 26-53.

10. Kolars, note 3 above; J. Waterbury, "Dynamics of Basin-Wide Cooperation in the Utilization of the Euphrates" (paper prepared for the conference *Economic Development of Syria: Problems, Progress, and Prospects*, Damascus, 6-7 January 1990); and Kolars and Mitchell, note 4 above.

11. Kolars, note 3 above.

12. This estimate comes from Thomas Naff of the University of Pennsylvania and is cited in "Water Wars in the Middle East," *The Economist*, 12 May 1990, 54-59.

13. Waterbury, note 10 above.

14. Naff and Matson, note 7 above.

15. *Middle East Economic Digest*, "Battle Lines Drawn for Euphrates," 13 October 1989, 4-5. See, also, Waterbury, note 10 above.

16. A. Cowell, "Water Rights: Plenty of Mud to Sling," *New York Times*, 7 February 1990, A4.

17. See P. Schweizer, "The Spigot Strategy," *New York Times*, 11 November 1990, op. ed.

18. These closed-door discussions were described to the author by the ambassador of a member nation of the UN Security Council under the condition that he remain anonymous. See, also, the statement of the Minister of State of Turkey, Kamran Inan, at the Conference on Transboundary Waters in the Middle East: Prospects for Regional Cooperation, Ankara, 3 September 1991. At that meeting, Inan stated that Turkey would never use water as a means of political pressure and noted that it had declined to do so during the Gulf War.

19. G. F. White, "The Environmental Effects of the High Dam at Aswan," *Environment*, September 1988, 4.

20. D. Hillel, *Out of the Earth: Civilization and the Life of the Soil* (Berkeley, Calif.: University of California Press, 1991).

21. "Agreement Between the United Arab Republic and the Republic of Sudan for the Full Utilization of the Nile Waters," Cairo, 8 November 1959, *Egyptian Review of International Law* 15, 321.

22. Cited by J. Starr in "Water Wars," *Foreign Policy* 82 (Spring 1991): 17-30.

23. This statement has been widely cited. As one example of the widespread attention it has attracted, it appeared in the major newspaper of Nairobi. See T. Walker, "The Nile Struggles to Keep Up the Flow," *Sunday Nation*, 10 January 1988, 11.

24. Priscoli and Brumbaugh, note 6 above.

25. *U.S. Water News*, "Iraq's Water Systems Still in Shambles," October 1992, 2.

26. United Nations Department of Economic and Social Development, *World Population Prospects: The 1992 Revision, Annex Tables* (New York, 1993).

27. Falkenmark, note 2 above. See, also, chapters 1, 7, and 9 in Gleick, note 2 above.

28. This article is not the place for a discussion of climate change per se. For more detail on the science of this issue, see the report of the Intergovernmental Panel on Climate Change, *Climate Change: The IPCC Scientific Assessment* (Cambridge, England: Cambridge University Press, 1990); P. H. Gleick, "Effects of Climate Change on Shared Fresh Water Resources," in I. M. Mintzer, ed., *Confronting Climate Change: Risks, Implications and Responses* (Cambridge, England: Cambridge University Press, 1992), 127-40; and S. H. Schneider, P. H. Gleick, and L. O. Mearns, "Prospects for Climate Change," in P. E. Waggoner, ed., *Climate Change and U.S. Water Resources* (New York: John Wiley and Sons, 1990), 41-74.

29. See the collection of articles in Waggoner, note 28 above; and P. H. Gleick, "Climate Change, Hydrology, and Water Resources," *Review of Geophysics* 27, no. 3 (1989): 329-44.

30. P. H. Gleick, "The Vulnerability of Runoff in the Nile Basin to Climatic Changes," *The Environmental Professional* 13 (1991): 66-73.

31. Gleick, "Water and Conflict," note 1 above; and S. Lonergan and B. Kavanagh, "Climate Change, Water Resources and Security in the Middle East," *Global Environmental Change*, September 1991, 272-90.

32. For a discussion of the importance of the term *equitable utilization*, see, for example, P. H. Gleick, "Reducing the Risks of Conflict over Fresh Water Resources in the Middle East," in J. Isaac and H. Shuval, eds., *Water and Peace in the Middle East* (Dordrecht, the Netherlands: Elsevier Science Publishers, 1993); and S. C. McCaffrey, "Water, Politics, and International Law," in Gleick, note 2 above, pages 92-104.

33. G. Baskin, "The West Bank and Israel's Water Crisis," in Baskin, note 9 above, pages 1-8.

34. Shuval, note 9 above. See, also, Al Khatib, "Palestinian Water Rights," in G. Baskin, ed., *Water: Conflict or Cooperation*, rev. ed., vol. 2, no. 2 (Jerusalem: Israel/Palestine Center for Research and Information, 1993), 13-22.

35. See, for example, R. H. Coppock and M. Kreith, eds., *California Water Transfers: Gainers and Losers in Two Northern Counties* (Davis, Calif.: University of California Press, 1993).

36. This concept was raised at the December 1992 "First Israeli-Palestinian Joint International Academic Conference on Water" held in Zurich, Switzerland. For initial discussion of minimum water requirements, see H. Shuval, "Proposed Principles and Methodology for the Equitable Allocation of the Water Resources Shared by the Israelis, Palestinians, Jordanians, Lebanese, and Syrians," and P. H. Gleick, "Reducing the Risks of Conflict over Fresh Water Resources in the Middle East," in Isaac and Shuval, note 32 above.

37. The "consumptive use" of water must be distinguished from water withdrawals. Consumptive use refers to water withdrawn and made unavailable for reuse through evaporative loss, percolation to deep groundwater layers, or contamination. In every country of the Middle East, the agricultural sector is responsible for the vast majority of the consumptive use of water. Reducing consumptive uses of water makes more water available for other uses.

38. M. F. Abu-Taleb, J. P. Deason, E. Salameh, and B. Kefaya, "Water Resources Planning and De-

DEVANEY STOCK PHOTOS

The Baro River is one of many in Ethiopia that drain into the Nile, on whose water both Egypt and Sudan are critically dependent.

velopment in Jordan: Problems, Future Scenarios, and Recommendations," in G. LeMoigne, ed., *Country Experiences with Water Resources Management*, World Bank Technical Paper 175 (Washington, D.C.: World Bank, 1992), 119-27.

39. Priscoli and Brumbaugh, note 6 above.

40. A. Hindley, "Power and Water," *MEED Special Report*, 19 January 1990, v-xiv.

41. K. Wangnick, *1990 IDA Worldwide Desalting Plants Inventory*, report no. 11 (Gnarrenburg, Germany: Wangnick Consulting, 1990); and Gleick, "Water and Energy," in Gleick, note 2 above, pages 67-79.

42. Kolars, note 3 above.

43. Priscoli and Brumbaugh, note 6 above.

44. Shuval, note 9 above.

45. UN International Law Commission, *Report of the International Law Commission on the Work of Its Forty-Third Session* (New York: United Nations, 1991).

46. S. C. McCaffrey, "Water, Politics, and International Law," in Gleick, note 2 above, pages 92-104.

47. Food and Agriculture Organization, *Systematic Index of International Water Resources Treaties, Declarations, Acts and Cases by Basin*, Legislative Study no. 15 (Rome, 1978). This index is irregularly updated.

48. Some progress has been made in this area with the Bellagio Draft Treaty of 1989: "Transboundary Groundwaters: The Bellagio Draft Treaty," revised and augmented by R. D. Hayton and A. E. Utton, *Natural Resources Journal* 29 (Summer 1989): 663-722.

Overview

(continued from page 5)

and contributed to a massive "social deficit," the rebels' fears cannot be dismissed as completely irrational.

A serious binational cooperative program to mitigate such costs might have averted this tragedy. As a small and, in retrospect, inadequate step, the Sierra Club called for new bilateral institutions and funding to ensure cleanup of the U.S.-Mexican border and for funding to beef up Mexico's environmental regulatory capacity. The new institutions NAFTA sets up to fund and manage border improvements are inadequate to their task. First, funding for the new North American Development Bank is unlikely to materialize after the first year because the U.S. Congress, concerned with arrears to existing multilateral lending institutions, is not likely to continue to appropriate funds. The bank should have been funded through polluter taxes or a small fee on transactions at the border. Second, despite environmentalists' efforts to open up multilateral development agencies to the public, the bank and the Border Environmental Cooperation Commission are closed, "vertical" institutions, with limited public involvement in their decisionmaking and tightly restricted access to information on their activities. For example, although, as Magraw pointed out, a majority of the commission's directors will be drawn from the border region, he neglected to mention that they will be appointed by the presidents of the two countries. As a workable and nonpaternalistic alternative, the directors should be elected directly by border residents. Mexico's record of top-down environmentalism does not bode well for the independence of the commission's directors.

Nevertheless, 1 January brought not only a new year but also a new starting line for efforts to "green" trade in North America. The split in the environmental community over NAFTA hid a great deal of agreement about the need to green trade agreements. It is incumbent on all of us to work to see that trade becomes an engine for sustainable development and does not endanger the high environmental standards in the United States.

Daniel A. Seligman
Sierra Club
Washington, D.C.

The views expressed in this article are the author's alone and do not represent an official position of the Sierra Club.

1. S. Charnovitz, "The North American Agreements on Free Trade and Environmental Cooperation: Green Law or Green Spin?" (paper prepared for presentation at the Conference on "NAFTA: Trade and the Environment," University of Virginia School of Law, 6 November 1993), 23-26.

2. C. K. Gunsalus, chair, Committee on Scientific Freedom and Responsibility, American Association for the Advancement of Science, letter to Fausto Alzati, director general, National Advisory of Science and Technology (sic), Government of Mexico, 5 October 1993.

3. Helen Ingram et al., U.S. EPA Integrated Border Environmental Plan Public Advisory Committee, letter to Carol Browner, EPA administrator, 20 July 1993.

4. General Agreement on Tariffs and Trade, "Industrial Pollution Control and International Trade," *GATT Studies in International Trade*, 1 July 1971, as cited in S. Charnovitz, "GATT and the Environment: Examining the Issues," *International Environmental Affairs* 4, no. 3 (Summer 1992).

5. R. Solorzano et al., *Accounts Overdue: Natural Resource Depreciation in Costa Rica* (Washington, D.C.: World Resources Institute, 1991), 4.

6. Costa Rica Bureau of Statistics, memorandum, 1994.

7. T. Roberson, "Bloody Indian Revolt Continues in Mexico," *Washington Post*, 4 January 1994, A1; and H. Aridjis, "Slaves and Guerrillas, Forests and Blood," *New York Times*, 5 January 1994.