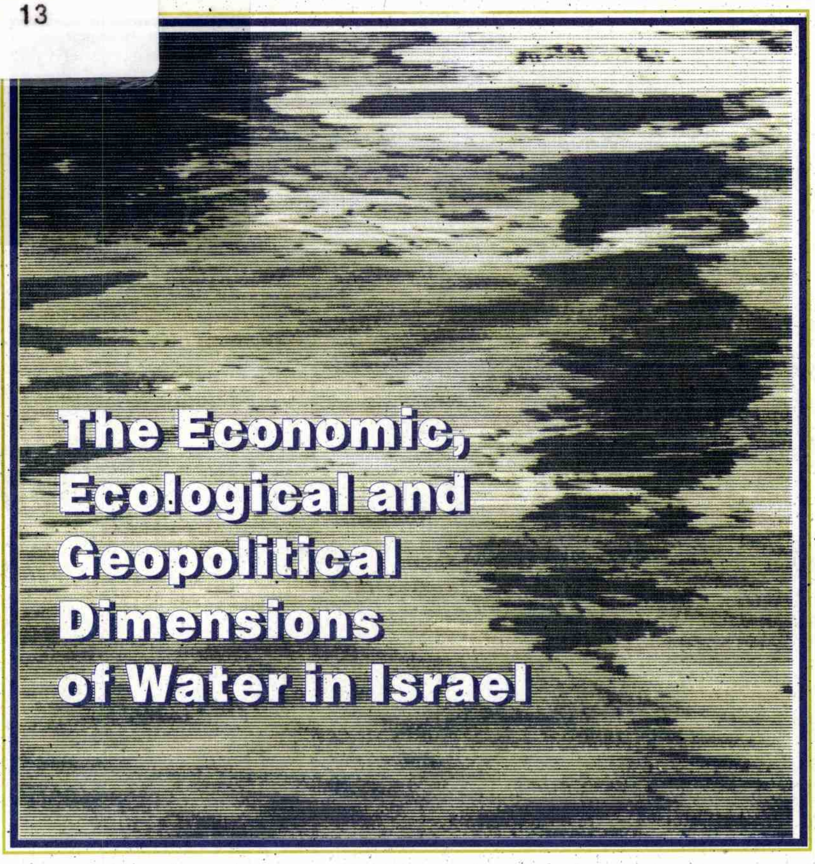

# The Economic, Ecological and Geopolitical Dimensions of Water in Israel

by
**Stephen C. Lonergan**
**David B. Brooks**

# ECONOMIC, ECOLOGICAL AND GEOPOLITICAL DIMENSIONS OF WATER IN ISRAEL

*by*

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The Centre for Sustainable Regional Development (CSRD) at the University of Victoria is a research centre supporting interdisciplinary work on environmental, economic, institutional, social and cultural sustainability. It provides information on sustainability and its applications to users regionally, nationally, and internationally.

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> Que n'a-at-on fait pour s'approprier l'eau? Que n'a-t-on inventé pour s'excuser de l'avoir fait? Quel crime n'a-t-on commis pour n'avoir pas à s'en excuser? Quelle raison d'état n'a-t-on invoquée pour s'en assurer la possession exclusive?
>
> (de Laet, 1992)

# I. INTRODUCTION

> And Lot also, who went with Abram, had flocks, and herds, and tents. And the land was not able to bear them, that they might dwell together; for their substance was great, so that they could not dwell together.
>
> (Genesis, 13:6)

Both Biblical and modern Israel have been vitally concerned with water. The first explicit ecological reference in the Bible relates to the carrying capacity of pasture and water supplies that were coming under stress from growth in the herds owned by Abraham and by his nephew Lot. One of the periodic droughts of the region starts the drama that leads to the Exodus story. More recently, the challenge to "make the desert bloom" brought Jewish settlers into what was first a Turkish colony and then a British protectorate. Later projects, such as the draining of the Hula wetlands and construction of the National Water Carrier, were hailed as symbols of the potential to live productively and comfortably in an arid region -- if at the same time they were described by Arabs as "aggressive expansionist ambitions threatening all Arabs alike" (cited in Rothman and Lowi, 1992, p. 62).

## Image and Reality

The State of Israel is commonly regarded as presenting a model of sound water management. The reality is, however, different from the image. Israel has done quite well in micro-level choices to ensure that water is consumed efficiently at the point of use; it has done much less well in macro-level decisions that allocate water among alternative uses and users. As a result, Israel is now confronting a water crisis, not in the future but at present.

### *Domestic Aspects*

The Israeli public has been made acutely aware of the nation's dependence on water and its vulnerability to water shortages. The whole region experienced a severe drought throughout the latter half of the 1980s, and continuing into the 1990s. Water reservoirs in Israel fell to historic low levels, and, for almost the first time in recent history, restrictions on water use were imposed, particularly on farmers. (Conditions were even worse in Jordan, where urban dwellers were without water for many hours a day.) The drought broke with heavy rains (and snow in Jerusalem and Amman) during the winter of 1991-92, but further droughts will occur.

This concern is not merely an academic issue. Water is essential for irrigated agriculture, and each political party in Israel has strong ties to agricultural areas. Tension rises to great heights when, as occurred two years ago, the State Comptroller claimed that favouritism toward farmers in water allocation and pricing had not only created the water shortage but was damaging the nation's fragile economy. Similar, if more moderate, tensions are present when the Ministry of the Environment suggests that agricultural and industrial pollution are endangering sources for drinking water and that municipalities should improve their sewer systems or industries their wastewater flows.

### *International Aspects*

Water is not solely a domestic issue, either. In Postel's (1992) words, the Middle East is "the most concentrated region of [water] scarcity in the world." The international aspects of Israeli water problems have four dimensions. First, the extent to which Israel's water supply originates in the Occupied Palestinian Territories is a source of much criticism both within and outside the country. Water is one of five topics being treated in separate multilateral peace negotiations that parallel the bilateral negotiations between Israel and each of her Arab neighbours. In the absence of an equitable and efficient resolution of Israeli-Palestinian water issues, no peace agreement can last for very long.

Second, insofar as the Jordan River is concerned, Israel is a strong, downstream riparian. This is a common situation in the Middle East; Egypt is in the same position on the Nile, and Syria and Iraq on the Euphrates. As Kolars (1990) points out, over half of the population in the Middle East and North Africa, outside the Mahgreb, depend upon water from rivers that cross an international boundary before reaching them, or they use desalinated water or water from deep wells. Policies and institutions developed for water resources shared by Israel and its neighbors are likely to be applied more widely in international water law.

Third, with its modern economy and western living standards, Israel exhibits a level and pattern of water demand that is currently atypical of the region. However, there is hardly a country in the region that is not experiencing alarming growth in its demand for water, and few are instituting significant conservation programs (Akkad, 1991; Hillel, 1991). Apart from the impact of Israel's military occupation of the Territories (an impact with long-term consequences that should not be ignored), solutions for water problems in Israel will have relevance for other Middle Eastern countries.

Finally, as Kolars (1990, p. 57) states, ". . . sharing of scarce water supplies is the single most important problem facing Middle Eastern populations." Kolars implies what others have stated flatly (eg, Starr and Stoll, 1988; Naff, 1990): namely, in the absence of sharing, a war over water -- probably the water of the Jordan River -- is likely if not inevitable. This makes water in this region not merely an example of environmental change and conflict but of environmental change and "*acute* national and international conflict," which is to say "conflict involving a substantial probability of violence" (Homer-Dixon, 1991, p.77; emphasis in original). Any such military action would likely be as futile economically as tragic for the people. "Going to war over water will solve little, since the reserves of all the disputants combined are sorely inadequate" (Shuval, 1992, p. 142).

## A Triple Crisis

With all of these factors playing a strong role, what had been a fairly technical subject has in recent years come to be more widely appreciated, as indicated by the number of articles appearing in the daily or weekly press.[1] At the same time, the number of references in professional journals and in the grey literature (unpublished reports etc.) is growing rapidly. The issue of water today is somewhat in the same position as energy in the early 1970s, subject to great concern and under study by a growing number of analysts, but prior to any apparent agreement as to resolution or even a common approach for resolution.

What *is* apparent, even at this time, is that Israeli water problems are not limited simply to considerations of scarcity, but are a result of three inter-related and interacting crises:

The first crisis is one of ***water supply and demand***. Since the mid-1970s, demand has outstripped supply. Population growth through natural increase and in-migration continue to put pressure on the water system, and many proposals for economic expansion would, if implemented, augment the pressure -- yet there is no evident way to increase supply.

The second crisis involves deteriorating ***water quality***. Much of the nation's water has been -- and is still being -- polluted by growing volumes of industrial and agricultural wastes, and in some cases by human sewage.

Finally, Israel's water crisis also has ***geopolitical dimension.*** Roughly one-third of the water consumed in Israel comes from groundwater that originates as rainfall over the West Bank -- on land that in any final settlement is likely to belong to Palestinians. The dependence of both peoples on the same water has led to what many have called a zero-sum game.

---

[1]As a sampling: New York Times (16 April 1989); Vancouver Sun (7 May 1991); The (Toronto) Globe & Mail (18 December 1991); Le Monde (29 January 1992); The Financial Post (31 January 1992); Guardian Weekly (24 and 31 May 1992). See also a series on water, including the Middle East, in the British science weekly, New Scientist; especially articles by Fred Pearce (1 June 1991 and 7 December 1991).

## Organization of this Study

The purpose of this monograph is to review each of the three crises (respectively, Chapters IV through VI) and to provide a set of regional options and policy recommendations for the future. However, before proceeding to study the crises, we first review briefly the geography, hydrology and climate of Israel, and, to a lesser extent, the Occupied Palestinian Territories (Chapter II). In addition, the structure of water supply and demand in Israel is discussed, as well as the infrastructure that has been developed to manage supply and demand in Israel and the Occupied Palestinian Territories (Chapter III). These two preliminary chapters are required partly because they provide the ecological and institutional bases from which all options for the future must begin, and partly because the interrelated nature of the three crises requires that solutions be found simultaneously for all three. The paper concludes with chapters presenting regional options for the future (Chapter VII), a preliminary set of recommendations (VIII), and conclusions (IX).

## Data: A Fourth Crisis

Concerns about data availability, validity and reliability are common to all studies of water supply and demand. However, in the Middle East, these concerns rise almost to the point of becoming a fourth "crisis." Water is a strategic resource: vital for state security, for human well-being, and for economic development. As such, many countries in the region keep most data on water availability and use confidential. In other cases, data may be released but be purposely misleading. In still others, data are not available simply because the country lacks any regular monitoring program.

Problems do not end even when data are available. Inevitably, one faces problems of measurement and sampling error, and of aggregation. Moreover, just as with energy, water suppliers are few and consumers many, so data on "consumption" are typically measured at the point of dispatch, not at the point of use. They almost never distinguish among end-users and end-uses below the level of three broad sectors: domestic, including municipal; agricultural; and industrial. Then, too, there is a problem with complementarity, as each country typically has its own set of data and is unwilling to accept the often conflicting data from another country or from an international agency.

These problems, which make analysis of water data and development of policy options problematic at best, are all exaggerated in the Middle East. Until recently, almost all data on water in Israel were treated as state secrets, and it is still said that journalists must submit articles on water for review by military censors. Palestinians complain vehemently that they cannot get access even to those data that are unclassified, and that any data provided to them are so massaged as to make the numbers useless for analysis. As well, Palestinians have been blocked from receiving some remote sensing data and satellite images because the international agencies that collect them can only release them to "states," and of course the Occupied Palestinian Territories are not formally a state.

The quality and availability of water data are central to concerns at the multilateral peace negotiations. Data issues also came forward strongly at an academic meeting in late 1992 of Israeli and Palestinian water specialists, and both sides, but notably the Israelis, pledged to work to improve availability in the shortest time possible.

All data used in this report are cited, and every attempt has been made to check the reliability of "rumours" that seem to pervade the literature on water in the Middle East.

## Some Definitions

Throughout the paper, we use "Israel" in two senses. From the perspective of political power, the term refers to the State of Israel, which at this time also includes the military administration of the West Bank and the Gaza Strip. From the perspective of geography, the term refers to land contained within the boundaries of pre-1967 Israel. (The pre-1967 borders are also implied by references to land "within the Green Line", which is essentially where armies were when a truce was declared in 1948.) We use "Occupied Palestinian Territories" to refer generally to areas under Israeli military administration. Where appropriate, we refer specifically to the West Bank or the Gaza Strip. However, information on the Gaza Strip is more limited than that on the West Bank, so in some cases we extrapolate from the latter to the former.

Definitional problems provide additional difficulties in dealing with water data. So far as water is concerned, "consumption" is an ambiguous term. It can refer to withdrawals from natural waterways, be they on the surface or underground. However, much of the water so withdrawn simply runs off fields or through industrial plants and back into the waterways. In a literal sense, only that proportion of the water that is evaporated (or evapotranspirated; ie, evaporated through the leaves of plants), drunk or incorporated into final products is truly consumed (Pearse et al, 1985). However, it is much more difficult to measure water consumption in this narrower sense. Moreover, even if the volume withdrawn and returned is identical, there is always some degradation in water quality.

The word "water use" is equally ambiguous. In addition to water used after withdrawal, water has flow uses (as with hydropower and dilution) and in-place uses (as with recreation, fisheries and habitat protection), which also have economic as well as esthetic value (Muller, 1985; Pearse et al, 1985). Except for hydropower and perhaps recreation, almost no account is taken (and not just in the Middle East) of flow or in-place uses.

For the purposes of this study, water consumption and use will be taken as synonymous. In almost all cases, they are measured at the point of water withdrawal, not of final consumption. Other definitions the reader may find useful are included in Box 1.

The unit of measure for water in this report is generally million cubic metres (Mcm) or litres (L). Each cubic metre contains one thousand litres; one litre is equal to 0.22 imperial gallons; so one cubic metre is equal to 220 imperial gallons. Rainfall is measured in millimetres (mm); 25 mm of rain equals about one inch. A useful standard is the 500 mm line, which is the minimum for growing wheat without irrigation.

Costs are all given in United States dollars of 1990 to 1991.

Because the conflict over water in the Jordan River basin is central to the broader conflict that "engaged two nationalist movements, each struggling for its right to national identify and national existence, while denying the adversary these same rights" (Rothman and Lowi, 1992, p. 57), Appendix A provides a succinct summary of the "claims, counter-claims, fears and concerns" of Palestinians and Israelis. It is adapted from a recent essay by Shuval (1992).

## Glossary

**Aquifers:** An aquifer is a bed of rock that is either permeable enough to permit water to flow through the pores (usually very slowly) or soluble enough to permit the water to create its own channel through which it can flow (generally more rapidly). Deeper wells and bore holes that can pierce rock are needed to tap aquifers.

**Catchment/Drainage Area:** The area that is drained by a river, or which contributes (eventually) to the flow of a river.

**Groundwater:** Water flowing underground. More than half of Israel's water comes from underground sources such as springs and aquifers.

**Groundwater Mining:** Pumping more water out of an aquifer than is contributed annually through precipitation or other form of recharge.

**Over-pumping:** Over-pumping or "mining" an aquifer implies removing more water than is replenished on an annual basis.

**Recharge Area:** The spatial extent of the area that recharges an aquifer; that is, any precipitation falling in the region will seep into the ground and replenish the aquifer, or any lake or river from which water seeps into the aquifier.

**Saltwater Intrusion:** Over pumping (or mining) an aquifer near the coast (such as the Coastal Aquifer in Israel) can "draw" in saltwater from deeper underground or from the sea.

**Surface Water Sources:** Water sources on the surface of the earth, such as rivers, lakes and seas.

**Wadi:** Stream or river that flows primarily during the rainy season in an otherwise arid region.

**Water Table:** The level at the top of underground water. Depending on the amount of precipitation and recharge, the water table can be raised or lowered.

# II. SOURCES OF WATER: NOTES ON GEOGRAPHY, HYDROLOGY AND CLIMATE

> And We send down from the sky rain charged with blessing. And We produce therewith gardens and grain for harvests.
>
> (Koran)

A major constraint to further economic development -- perhaps *the* major constraint -- faced not just by Israel, but by most countries in the Middle East, is the limited amount of rainfall. Compared with other countries in the region, the availability of water in Israel is about average: less well endowed than Lebanon, Syria and Turkey; about equivalent to the countries of North Africa; and much better endowed than Jordan and countries of the Arabian peninsula. (See Figure 1, which plots countries against a set of water stress codes introduced by Falkenmark, 1989.)

The West Bank is relatively well endowed with water resources, though much of the water could only be exploited with capital-intensive techniques (Heller and Nusseibah, 1991; Zarour and Isaac, 1991). Gaza, in contrast, is perennially short of water and has been in a water deficit position for a number of years (Bruins et al, 1991; Shawwa, 1992). Apart from Gaza and the Negev, the main water problem for both Israel and the Occupied Palestinian Territories is less total availability than seasonal and regional variations in availability, a point to which we will return below.

## Varied Geography and Topography

Lying along the eastern shore of a sea, and at the junction of four geographic and ecological zones, Israel's ecology is more varied than that of most other countries in the region, indeed than most others in the world. Within the relative small area of 20 thousand square kilometres, ecologists have identified 2600 plant species (130 of which are indigenous to Israel), 480 bird species, 70 mammalian species, and 90 reptile species (Gabbay, 1992).

Geographically, Israel can be divided into three zones aligned in a north-south direction (Reifenberg, 1955; see Figure 2). The most westerly is the coastal plain, 15 to 20 km wide, facing the Mediterranean Sea. It lies several tens of metres above sea level and contains most of the nation's population and industry. The Gaza Strip is found at its most southerly point, abutting the border with Egypt. The middle zone consists of the Judean hills, which are deeply dissected but include peaks over 800 metres above sea level. This chain forms the watershed between land sloping gradually (except in the north) westward to the Mediterranean and land sloping (much more steeply) eastward to the Jordan Valley and Dead Sea. The third

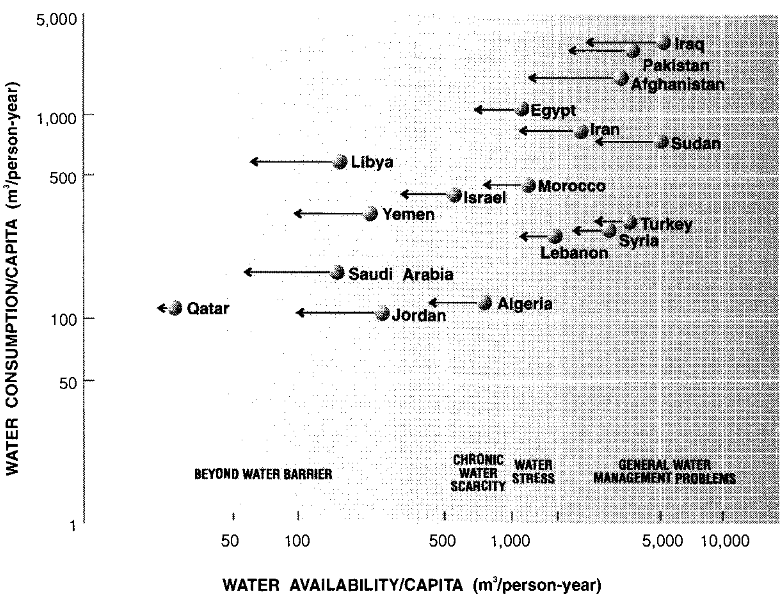


*Figure1. Water stress codes, selected Middle East countries, 1988 - 2020*

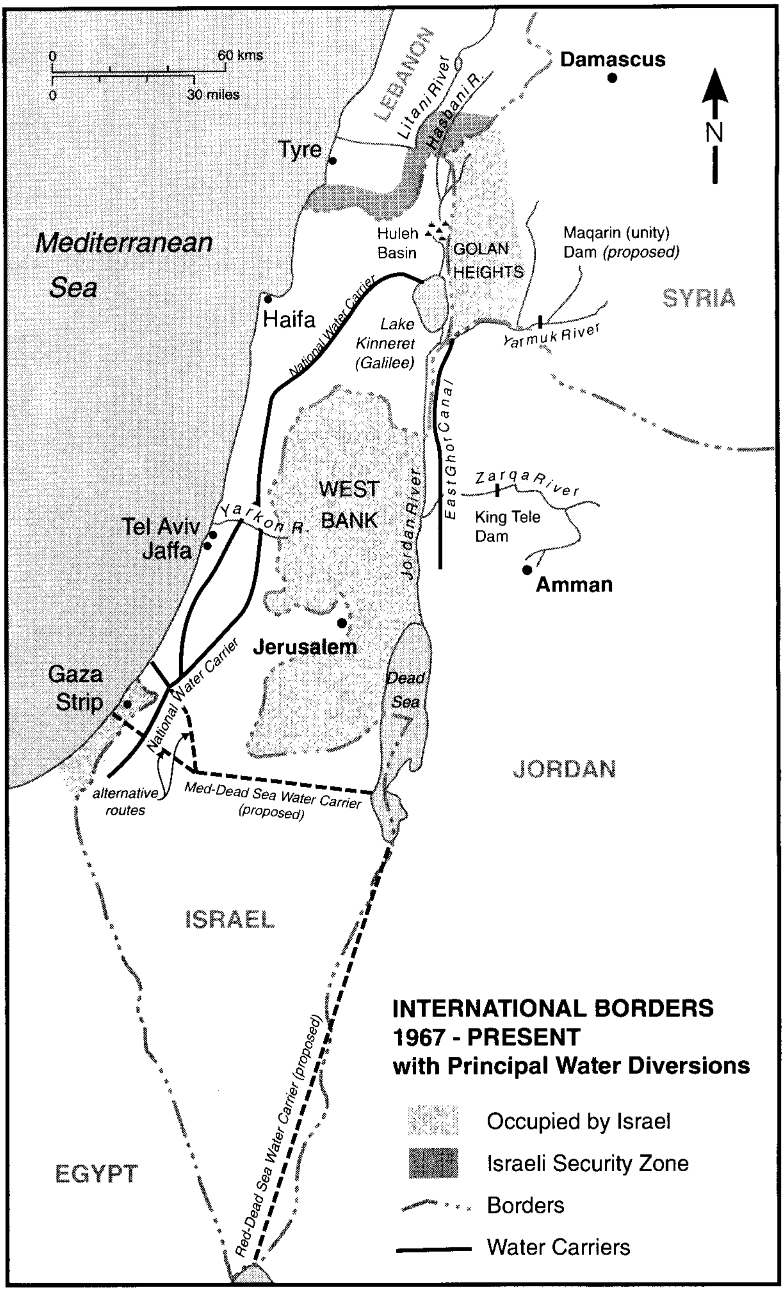


*Figure 2. Map of the Jordan River Basin, with water pipelines (existing and proposed)*

zone is the Jordan Valley itself, which forms the northern limit of the Great Rift Valley of Africa. The West Bank includes the eastern slope of the mountainous middle zone plus the northwestern shore of the Dead Sea and northward for about two-thirds of the length of the Jordan River.

## CLIMATE AND VARIATIONS IN CLIMATE

Israel's climate is equally varied. Prevailing southwesterly winds blow off the sea in the north, bringing substantial moisture, while the same winds blow from Egypt in the southern parts of the country and are devoid of moisture. The resulting climate ranges from almost subtropical in the north (subalpine on the upper slopes of Mt. Hermon, at the northern end of the Golan Heights) to quite arid in the Negev Desert only 500 kilometres to the south. It is also variable throughout the year, with the typical Mediterranean cycle of hot, dry summers and mild, rainy winters. Rainfall averages 1000 millimetres per year in parts of Galilee in contrast to 20 mm in the southern Negev. Changes in rainfall occur over short distances; for example, the Gaza Strip is only about 45 km from north to south, but rainfall averages 350 mm per year at the northern end and only 150 mm at the southern (Zarour and Isaac, 1991).

Variations in climate, and particularly in rainfall, do not end with season and location. Even greater variations occur from year to year, with the region lurching from successive years of drought or near-drought conditions to other years of rains so heavy as to causing flooding and loss of life. Over just a few years, annual rainfall may vary by a factor of ten -- that is, ten times as much rain falls in some years as in others. As a result, reliable flow -- defined as the discharge that could be expected 90 percent of the time, or during nine years out of ten (Foster and Sewell, 1981) -- may be only 5 to 10 percent of average flow in the Jordan River basin. (By way of comparison, reliable flow is 60 to 80 percent of average flow in Ontario and Quebec, and 30 percent in the southern Prairies of Canada.)

These year-to-year variations in rainfall in the Middle East have enormous implications for water planning and management. Extreme years must be treated as normal, not abnormal, events, which implies emphasis on risk minimization. *Therefore, for either short-term or long-term water planning, it is much more important to have a good understanding of the spatial, seasonal and annual variations in rainfall than of annual or national averages.*

## Hydrological Conditions

Given this ecological and climatological situation, it is hardly surprising to find that hydrological conditions also vary, both from north to south and from winter to summer. More than 85 percent of the country's surface water resources are located in the north. By far the largest river is the Jordan, which flows into Lake Kinneret (the Sea of Galilee), a natural freshwater lake located 209 metres below sea level, and then along the border between the Occupied Palestinian Territories and the nation of Jordan until it disappears into the Dead Sea (Figure 2). Despite such quantitative dominance, the entire flow of the Jordan is only equal to about one-third of Israeli water consumption, and both ecological and political considerations limit the amount Israel can take. Most of the other rivers, such as the Yarkon in Tel Aviv and the Kishron in Haifa, are short and flow from the Judean Hills westward to the Mediterranean through the most populous region of the nation.

Spatial and temporal variations in water flow pose a severe distributional problem for Israel. Rainfall and water storage is concentrated in the north, whereas demand arises primarily from the heavily populated coastal regions and the agricultural areas in the southern half of the country. To complicate the situation, water demand for both urban and agricultural uses peaks during summer, but almost all the rain falls during four winter months. The not-surprising result is strong emphasis on maximum use of Kinneret, the one natural storage reservoir, and construction of extensive artificial storage capacity. The Yarmuk, which forms the border between Jordan and Syria before it enters Israel and joins the Jordan just below Kinneret, has a very high winter flow that is currently used to dilute the increasingly saline water of the Jordan. Several plans for storage and controlled release of this water have been made by Jordanian and Syrian officials, presumably with some allowance for use on the West Bank, but implementation has always been blocked -- originally by lack of agreement between Jordan and Syria and, more recently, lack of agreement from Israel.

Modern Israel would not be possible if she had to depend entirely on surface water. Today (and historically) the more important sources of water have been subsurface, mainly aquifers. In central Israel, water supply comes from two large aquifers, the Coastal Aquifer and the larger Yarkon-Tanninim (or Mountain) limestone aquifer (Figure 3). This latter aquifer is actually a compound of several separate aquifers, all of which flow from west to east, under the Green Line and onto the coastal plain. In addition, there are two other aquifers (Cenomenian-Judean) which flow northwestward to the Beit She'an and Jezreel Valleys. Finally, one relatively small aquifer with a renewable flow of 125 million cubic metres (Mcm) flows eastward into the Jordan Valley and does not affect Israeli supplies (Zarour and Isacc, 1991). Together, these aquifers now account for more than half of all sweet (non-saline and non-recycled) water used in Israel.

Geographic, climatic and hydrological conditions simply provide the backdrop on which the structure of human use of water is presented. In some parts of the world, these conditions allow for ample water availability, but in arid and semi-arid regions, such as that of Israel, they are ultimately limiting. As Falkenmark and her colleagues (1989) have emphasized, such regions are vulnerable not merely because of water scarcity and intermittent droughts but also because they are particularly susceptible to stresses engendered by humans through mis-use of land (leading to "landscape desiccation") and through population growth. What is even more problematic is that appropriate ways of dealing with these problems are generally small in scale and locale-specific, but typical approaches to them have "a frontier philosophy, manipulating natural systems to whatever degree engineering know-how would permit" (Postel, 1993, p. 23). Accordingly, we now turn to the specific ways in which water resources are used and managed in Israel.

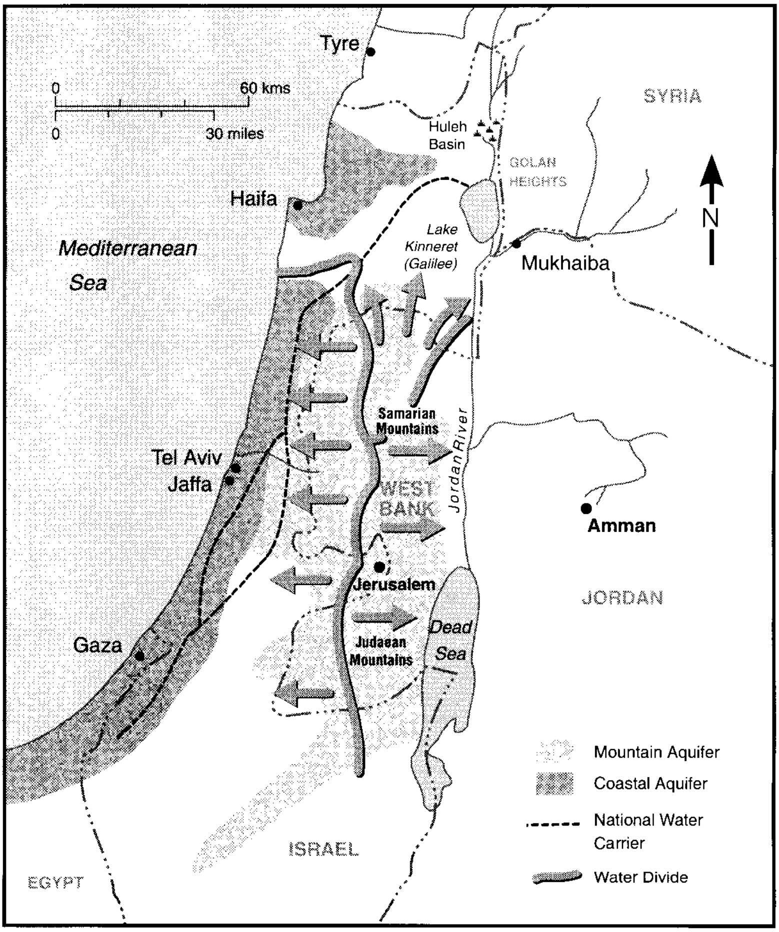


*Figure 3. Map of the mountain and coastal aquifers, Israel and the Occupied Palestinian Territories*

# III. WATER SUPPLY AND DEMAND: STRUCTURE AND INFRASTRUCTURE

> For the Middle East has undergone an amazing decline from former times of more numerous populations, higher standards of living, much better agriculture, and more general irrigation of farm lands, and better practices of soil conservation.
>
> (W.C. Lowdermilk, introduction to Reifenberg, 1955)

Water, its availability or lack thereof, has been the historic resource problem not just of Israel but of the whole region. Neither local nor regional politics can be understood without reference to water (surface and underground), nor can patterns of water supply and use be understood without reference to internal and external politics (Lowi, 1991; Hosh and Isaac, 1992), and even to culture (Rothman and Lowi, 1992).

The region has long suffered from mis-use of both land and water resources (Reifenberg, 1955). Hillsides have lost their vegetative cover, streams that were once perennial now dry up shortly after a rain, and productivity of fields and orchards have declined. A secular trend to lower rainfall may account for part of the degradation problem, but the greater part appears to be anthropogenic. Since creation of the State of Israel, enormous efforts have been made to restore land to earlier, more productive conditions (Hillel, 1991), but, as will be described below, the same kind of attention has not been paid to the water resources that interact with land to promote sustainable ecologies and economies, nor has the same kind of attention been devoted to land and water lying outside the Green Line.

In Israel, the structure of supply and demand for water, the infrastructure of water management, and the geopolitics of water are all inter-linked. This is to be expected. For one thing, the boundaries of surface water supply sources do not coincide with political boundaries. As has been true since Biblical times, control over lakes and rivers in many parts of the world is very much in dispute. The same is true of groundwater, and in this case the problem is compounded because of the absence of any agreed body of international law (Hayton and Utton, 1989; see section VII.A.2, below). (Ironically, in the case of Israelis and Palestinians, the difficulties are compounded by the remarkably close overlap, as shown in Figure 3, of the geological position of the Mountain Aquifer and the political boundaries of the West Bank.) And, finally, throughout the region one finds major reliance on megaprojects to couple regions of high demand with those of ample water availability, and such projects involve either international effects on resources or international sources of capital -- or, most commonly, both.

## CONSUMPTION

Water consumption in Israel, by sector, between 1958 and 1991 is depicted in Table 1 and Figure 4. Broad comparisons to Canada, by any standard a water-rich country, and to Jordan, by any standard a water-poor country, are presented in Table 2. The most glaring difference is between non-agricultural water use in Canada and in either Israel or Jordan, a difference that reflects differences in both climate and lifestyles or habits. However, smaller differences are also relevant. Non-agricultural water use in Israel is twice that in Jordan, a result, among other things, of greater resource availability and the use of water to provide a high quality of urban life in Israel. Both nations are comfortably above the 100 litres per person-day generally regarded as the minimum necessary for human health and hygiene.[2] (As will be discussed below, this is not the case for the Gaza Strip.) In contrast, despite similar crops, Israel uses less than one-half as much irrigation water per hectare as does Jordan, the difference being the result of more advanced (and more capital-intensive) technology. Given the difference in climate, the data also suggest that irrigation is more efficient in Israel than in Canada.

---

[2]Each cubic metre contains 1000 litres, so litres per day can be derived from cubic metres per year by dividing by 365 and multiplying by 1000. At the extreme, Bedouins may use as little as 15 to 30 litres of water per day.

Israel's fresh water demand approaches 1900 Mcm per year (although it is much lower in drought years; see Table 1). (Another 150 Mcm of saline water is used in agriculture, and 30 Mcm in industry.) Other estimates have reported total consumption as low as 1700 Mcm and as high as 2100 Mcm (in 1989), differences that exemplify the difficulty in deriving accurate water balances for the region. The primary consumer is agriculture, and the dominant use is irrigation, which takes approximately 1200 Mcm of sweet and recycled water every year (just over 70 percent of total consumption if saline water is included; just under if it is not). Domestic and municipal uses, which include everything from households and hotels to urban gardens and fire protection, account for just under one-quarter of total use. Israeli industry accounts for less than 7 percent of total use.

Most of Israel's consumption occurs within the Green Line, but 40 to 50 Mcm per year are taken directly by Israeli settlements in the Occupied Palestinian Territories (Zarour and Isaac, 1991; Lowi, 1992). Demand for water in the settlements has been rising faster than population, as a result of increasing per capita demands for both irrigated acreage and domestic amenities. Therefore, water use could continue to increase even if the number of settlements remains steady.

Water use per capita and per dollar of output has fallen dramatically over the past 30 years because of efficiency improvements (Hillel, 1991; Gabbay, 1992). Drought-enforced reductions in allocations to the agricultural sector are responsible for much of the drop in consumption since 1989. Despite these relative gains, absolute consumption remains high, due to continued growth in population and in economic output, and a crisis of water supply is evident almost every year and magnified during times of drought.

**Table 1. Freshwater consumption in Israel, by sector, 1958 - 1991 (million cubic metres)**

| Year | Domestic | Industry | Agriculture | Total |
|---|---|---|---|---|
| 1958 | 196 | 46 | 1032 | 1274 |
| 1964-65 | 199 | 55 | 1075 | 1329 |
| 1969-70 | 240 | 75 | 1249 | 1564 |
| 1975-76 | 305 | 95 | 1328 | 1728 |
| 1979-80 | 375 | 90 | 1235 | 1700 |
| 1981-82 | 385 | 103 | 1282 | 1770 |
| 1983-84 | 419 | 103 | 1356 | 1878 |
| 1985-86 | 450 | 103 | 1434 | 1987 |
| 1987-88 | 447 | 123 | 1179 | 1749 |
| 1989 | 501 | 114 | 1236 | 1851 |
| 1990 | 482 | 106 | 1157 | 1745 |
| 1991 | 445 | 100 | 875 | 1420 |

*Source: Statistical Abstract of Israel, 1985; 1988; 1992.*

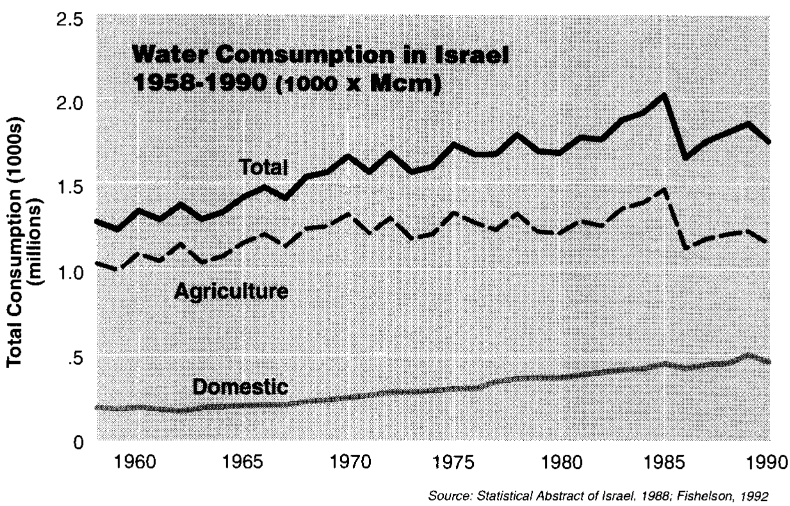


*Figure 4. Water consumption in Israel, 1965 - 1989*

**TABLE 2. COMPARATIVE DATA ON WATER CONSUMPTION: ISRAEL, JORDAN AND CANADA**

| | Israel | Jordan | Canada |
|---|---|---|---|
| Population, millions (1990) | 4.8 | 4.2 | 25.6 |
| GDP $M US (1990) | 53 200 | 3 330 | 570 150 |
| Irrigated Land, million hectares (1989) | 215 | 56.4 | 920 |
| **Water Use/Year, Million cubic metres Irrigation (1990)** | **1 200** | **534** | **3 559** |
| **Water Use/Year, Million cubic metres Other (1990)** | **550** | **288** | **38 651** |
| **Water Use/Year, Million cubic metres Total (1990)** | **1 750** | **822** | **42 210** |
| Water Use cubic metres, per capita, per year | 364 | 196 | 1 655 |
| Water Use litres/GDP per year | 32.9 | 246.8 | 74.0 |
| Non-irrigation Water Use cubic metres, per capita, per year | 114.6 | 68.6 | 1 510 |
| Irrigation Water Use cubic metres, per irrigated hectare per year | 5.6 | 9.5 | 3.9 |

## AVAILABILITY (1): PRINCIPAL SOURCES

Israel exploits three natural sources of fresh water for its needs, as noted above: Lake Kinneret (and the sources of the lake); large aquifers, notably the Yarkon-Tanninim (or Mountain) Aquifer, which extends from the West Bank into Israel, and the Coastal Aquifer; and smaller aquifers and streams within its own boundaries.

### *Surface Water*

It is estimated that Israel's renewable water resources equal approximately 1400 Mcm per year, with an additional 360 Mcm added through re-use programs and some 60 to 100 Mcm from collection and storage of storm run-off (Beaumont, 1989; McDonald and Kay, 1988; Kolars, 1992; see Table 3). Total river flows account for somewhat over one-third of the total, with 90 percent of that coming from the Jordan. Northern tributaries to the Jordan River, which deliver approximately 540 Mcm to Lake Kinneret (Kolars, 1992) come from Lebanon (the Hasbani River), Israel (the Dan Spring) and the Golan Heights (the Banias River and Hermon Spring). These flows combine with local runoff and precipitation to represent the total inflows to the Lake, which has a total storage capacity of approximately 4000 Mcm. The National Water Carrier, which is the main distributional system for water from Lake Kinneret south to the Negev (see Figure 2) draws annually 500 Mcm from the Lake. Roughly 70 Mcm of water passes out of the Lake to the Jordan River, which then combines with the Yarmuk River, the Zarqa River, various salt springs and precipitation/runoff for an annual flow of 697 Mcm (and a salinity of 2000 ppm) by the time it reaches the Dead Sea (refer to Figure 5 for a schematic diagram of Jordan River water flow). No major additions to surface water are expected in the future except through greater use of recycled wastewater, water harvesting, and desalination of brackish water in special areas (see below).

### *Underground Water*

As indicated above, the major source of fresh water in Israel is derived from underground sources. Israel has long tapped the Coastal and Mountain Aquifers, and these remain the principal sources of supply. Total renewable groundwater potential is estimated at approximately 850 Mcm per year (Table 3), although discharge figures vary from about 650 to 900 Mcm per year (Lowi, 1991). Just over twice as much is taken from the Mountain Aquifer as from the Coastal. The West Bank is also underlain by aquifers that flow in several directions. However, the Gaza Strip has only a single, relatively shallow fresh water aquifer that, it is claimed, is cut off from other parts of the Coastal Aquifer. (A larger and deeper aquifer is too salty for direct use.) Even before the 1967 War, Israel was exploiting two of three aquifers under the West Bank, and since the War the third source has been tapped for an additional 66 Mcm annually (Anderson, 1988).

**TABLE 3. SOURCES OF FRESH WATER IN ISRAEL, 1972 AND 1990 ANNUAL SUPPLY, MILLION CUBIC METRES**

| | 1972 | | 1990 | |
|---|---|---|---|---|
| Total Ground Water | | 830 | | 840 |
| Sandstone Aquifer | 240 | | 230 | |
| Limestone Aquifer | 590 | | 610 | |
| Total Surface Water | | 610 | | 650 |
| Jordan Watershed | 570 | | 570 | |
| Flood & Storm Water | 40 | | 80 | |
| Total Recycled Wastewater | | 39 | | 360 |
| Domestic | 35 | | 300 | |
| Industrial | 4 | | 60 | |
| Desalinated Water | | 1.0 | | 40 |
| **Total Available Fresh Water** | | **1 480** | | **1 890** |

All aquifers are vulnerable to declines in water levels as a result of excessive pumping, which reduces the water level and permits the intrusion of salt water from nearby saline aquifers or from the Mediterranean. Already, some 10 percent of the wells tapping the Coastal Aquifer yield water that exceeds the national limit for chlorine salts, and the percentage is increasing year after year. Maintaining the level and quality of water in the Mountain Aquifer is a prime objective of Israel's water policy.

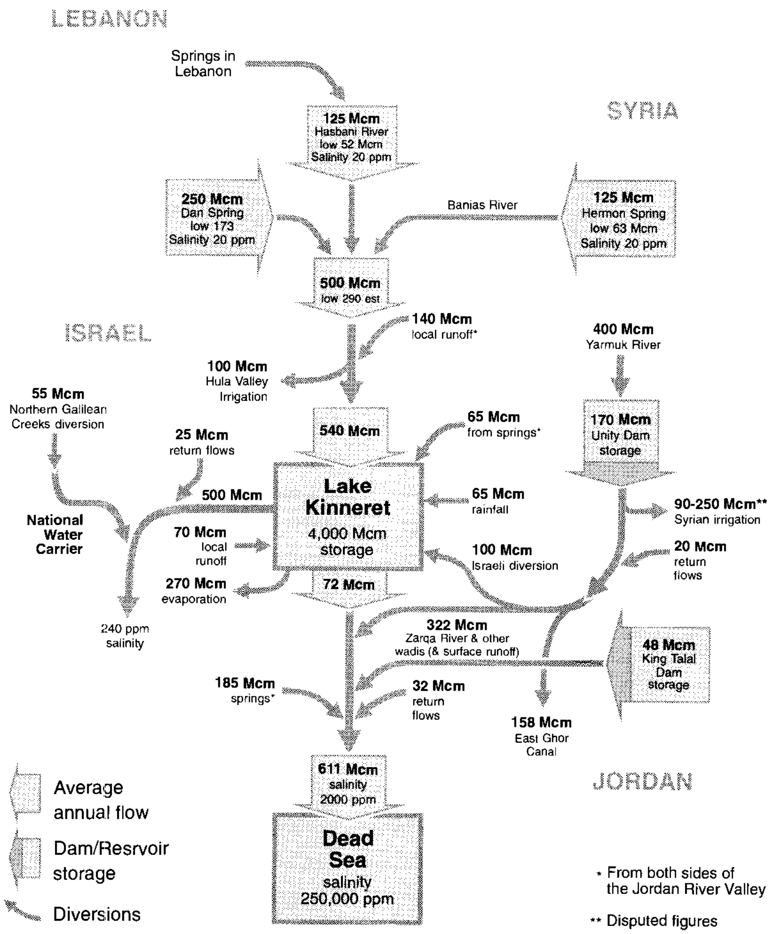


*Figure 5. Schematic diagram of Jordan River water flow*

## AVAILABILITY (2): SUPPLEMENTAL SOURCES

Conventional surface and groundwater sources are no longer adequate to meet the demands of a growing population and an expanding economy. There are, however, other sources available. By the year 2000, Israeli water use is expected to grow by 150 Mcm per year, entirely from expansion in the use of treated wastewater and of water harvesting methods (Gabbay, 1992). At that time, sources should come 52 percent from aquifers and springs, 31 percent from the Jordan River and its tributaries, 12 percent from treated wastewater and saline water, and 5 percent from harvested rainwater. By early in the next century, Shuval (1992) expects recycled water to be one-third of the total for both Israelis and Palestinians.

### *Recycled wastewater*

Recycled wastewater and water harvesting (collection, storage and later use of storm run-off) are two other sources that can now be treated as conventional even though their application is still uncommon outside the Middle East. Israel is among the world leaders in recycling sewage, and it now accounts for almost 20 percent of total supply, up from 3 percent two decades ago (Table 3). Some 70 percent of the wastewater collected in sewers is being re-used (Avnimelech et al, 1992). According to the Ministry of the Environment, recycled sewage effluents "constitute the most readily available and cheapest source of additional water, and provide a viable solution to Israel's water scarcity problem" (Gabbay, 1992, p. 60). By the end of the century, recycled wastewater could provide 400 Mcm of water per year for irrigation. Former Water Commissioner Meir Ben Meir has said that irrigated crops in Israel will eventually be fed only with recycled wastewater.

Recycled wastewater is mainly used for the irrigation of non-food crops and animal fodder, and also for recharging aquifers. Mekorot's (the national water authority) quality standard for recycled water provided to agricultural consumers is "drinking quality, but drinking not advised." While it is acceptable to drink the water occasionally, but it is inadvisable to do so on a regular basis, since the heavy metals in the water will accumulate in the body over time (Moore, 1993). Most of the cotton grown in Israel, for example, depends upon reclaimed rather than fresh water. However, after secondary treatment and storage for a time in an aquifer, some recycled water is chlorinated and released for unrestricted use in irrigation. Despite its benefits, recycled water must be used with caution because of the potential for toxic chemicals and pathogens, which cannot always be completely removed by conventional wastewater treatment, to enter the food chain. As well, aquifers can show adverse effects from continued use of reclaimed (or brackish) water. All use of recycled water requires a permit from the Ministry of Health. Continuous monitoring has indicated the safety of recycled wastewater provided treatment levels are high enough (Gabbay, 1992).

Israeli practices for recycling water are now well established and are being adopted or adapted by other countries in the region (Aboukhaled, 1992; Khouri 1992). However, the European Community has recently moved to prohibit all importation of produce irrigated with recycled wastewater. Although not yet accepted by all members, this could affect the use of the technique. At present no crops exported from Israel (except certain fruit trees) are irrigated with recycled water, so the initial impact on the Israeli economy of such a policy would be small. However, the policy would affect plans to shift agriculture completely to recycled water, as suggested by Ben Meir.

### *Water Harvesting*

Water harvesting is a technique for constructing small, typically micro-scale, dams and trenches to gather and make optimal use of rainfall and storm run-off. It was their knowledge of water harvesting that permitted the Nabateans and other desert dwellers to establish such rich civilizations in the desert two thousand years ago (Hillel, 1991; Pearce, 1991a). These techniques are now being rediscovered and, with the aid of computers and highly sensitive mapping, adapted to modern requirements. Their main uses in Israel have been for growing trees and shrubs in areas where rainfall is less than 300 millimetres per year, for halting desertification at the northern edge of the Negev, and for directing rainwater into channels that recharge aquifers rather than allowing it to evaporate. Perhaps the most important new application is known as savannization (Gabbay, 1992), an application of water harvesting to permit the growth of widely spaced tress in a carpet of grasses so as to exploit both winter rains and deeper soil moisture, while protecting the soil and the aquifers.

### *Use of Brackish Water*

Brackish water (that is, water that contains some salts but is less salty than seawater) from aquifers can be used for irrigating salt-tolerant crops and strains, which Israel has specialized in developing (Golani 1986). As indicated above, Israel is already using some 180 Mcm per year of saline water for agricultural and industrial purposes. While most saline aquifers are isolated and thus nonrenewable, and while pumping costs are far from negligible, the potential for greater use, particularly in the sandy soils along the coastal plain, is significant. Citrus trees, for example, cannot tolerate salty water while olive, fig and date trees can. Broccoli, tomato, spinach, beet and other vegetables can also be grown in salty water -- but only if drip irrigation methods are used, which means that the system is capital intensive.

## AVAILABILITY (3): DESALINATION

There are, of course, higher tech alternatives for new supply, notably cloud seeding and desalination. Cloud seeding has never been very successful. Although it has its supporters, all admit that seeding would provide only a marginal addition to available rainfall.

### *Desalinating Seawater*

Israel and her neighbours have all looked longingly at desalination for 30 years or more (United Nations, 1964). Its appeal is easy to understand. One might say that desalination is to water as nuclear power is to electricity -- the promise of unlimited supplies coupled with the curse of high costs, environmental problems, and megaproject fragility. At present, Israel has a 1500 cu.m. desalination plant at Eilat, and a 6000 cu.m. plant is under construction (with another 6000 cu.m. plant being planned).

Most studies have found that the high costs and energy requirements for desalination make its future as a major source of supply questionable. Production costs for plants that start with seawater are typically reported to be at least $1 per cubic metre and possibly twice that. As Weber (1991) writes, "Only the world's elite get their water from the sea." The process requires enormous quantities of energy (either to boil the water for distillation or force it through a membrane that extracts the salt), so it is not surprising to find that 60 percent of the world's desalination capacity is located in oil-exporting countries of Arabian peninsula. Nor is it surprising that, prior to its evacuation, Iraq destroyed Kuwait's desalination plants. (Kuwait has no stable supply of fresh water.) Even with low oil prices, reported production costs for desalinated water are five to ten times what urban dwellers pay for *delivered* drinking water and enormously more than what farmers pay.

A few analysts believe that the figures cited above exaggerate the cost of desalination. Dan Hoffman (1992a), from a firm called ADAN based in Tel Aviv, has suggested that a combination of reverse osmosis and low-temperature multi-effect distillation can reduce both operating energy and initial capital requirements, so that final (plant-gate) costs would be $0.65 to $0.70 per Mcm. The two technologies contain an independent power system and are matched with a turbine generator that discharges steam to the distillation plant and electricity to the reverse osmosis plant, a "total energy" scheme that Hoffman says can achieve overall thermal efficiencies of 80 percent or more. The plants are deliberately designed to be relatively small and modular -- 40 Mcm per year at a capital cost of $143 million. (including the 25 MW steam turbine). Even these costs are twice those of conventional supply in Israel. Seawater desalination should therefore be seen as an option for the longer term, and possibly then only if lower cost options for demand management and structure shifts are ignored.

### *Canals to the Dead Sea*

An alternative to stand-alone plants for desalination in the near future lies with the renewed interest in Med-Dead or Red-Dead proposals to bring seawater from either the Mediterranean Sea or the Red Sea and convey it by means of tunnel and canal to the Dead Sea (see Figure 2). Because of the 400 metre difference in elevation, the projects were originally conceived as a means of generating electricity (and replacing water in the rapidly diminishing Dead Sea basin). Although part of the electricity generated would be required to pump water across the Judean Hills (in the case of Med-Dead) or along the Jordanian border (in the case of Red-Dead), the plans alleged that enough would remain to power a substantial agro-industrial complex and thus make the projects viable. Plans for the Red-Dead Canal have now been re-conceived so that all the electricity generated would be devoted to desalination and thus reduce by about two-thirds the external energy requirements (Gur, 1985). Viability would be enhanced by the supply of fresh water to potential agricultural land and industrial plants. The estimate cost is approximately $2 billion, with a series of hydroelectric stations (costing $340 million each) generating electricity and producing desalinated water at half the current cost (Moore, 1993). The Italian government has already expressed interest in participating in the project.

Of the two routings, the Red-Dead appears to be the easier and cheaper -- for one thing, it avoids the need for tunnelling through the Mountain Aquifer -- but is inconceivable in the absence of a formal peace treaty between Israel and Jordan. Currently, the "Gur plan," which lies entirely within Israel, is attracting most attention. Fresh water from springs feeding the Upper Jordan would be diverted to recharge the Coastal Aquifer in order to restore its original level and quality. This water would be replaced by desalinated water, which would be pumped back up to Lake Kinneret and have the added benefit of improving water quality in the Lower Jordan (now too saline for use).

While one or another of these desalination proposals surfaces from time to time, any routing or diversion would cost billions of dollars and both raise very important environmental questions. None is likely to be implemented within a time frame that is relevant to the decisions needed about resolving current water problems.

### *Desalinating Brackish Water*

Brackish water containing 500 to 5000 parts per million (ppm) of total dissolved solids can be desalinated for $0.40 to $0.60 per cubic metre, about one-third the cost of desalinating seawater (World Resources Institute, 1992). Water for Eilat at the southern tip of Israel has for many years been supplied by a plant that desalinates brackish water pumped from an aquifer. A few other small plants were built at remote locations not served by the National Water Carrier.

The most common method for desalinating seawater is distillation, but reverse osmosis, which involves the use of high pressure to force the water through a membrane that filters our solids, now accounts for about one-third of world capacity (Ibid.). Hoffman (1992b) argues that marginally brackish water (up to 1250 ppm) is better treated by nanofiltration, an alternative membrane process that operates at low pressure and therefore has energy requirements under 1 kWh per cubic metre. He cites capital costs for a plant that would 100 Mcm per year to be just over $100 million with the desalinated water costing $0.25 - $0.27 per cubic metre. In combination with brackish water reverse osmosis, he also argues that the process could be used to reduce salinity levels in sewage for municipal use or for recharging the Coastal Aquifer (where purification would be completed). An added benefit would be the reduction of water hardness so use of detergents and water softeners could also be reduced.

If desalination has a near-term future, it is more likely to lie with brackish water than seawater. Some 27 percent of world desalination capacity now uses brackish feedstock, and the share is growing (World Resources Institute, 1992). Costs are not more than twice those of conventional supply, and some decrease can be expected. Large reserves of low to moderately brackish water occur in aquifers in the Middle East that could be tapped with conventional drilling equipment. Much of this is fossil water that is nonrenewable, but reserves can be large enough to amortize a sizable plant.

## Infrastructure, Management and Planning

As a result of the importance of all fresh water, a great deal of emphasis has been placed on developing a comprehensive water management scheme for Israel (Beaumont et al., 1988). All water resources in Israel belong the State. Management decisions on water quantities, production and the supply system rest with the Water Commissioner, who reports to the Minister of Agriculture. Few powers escape the Water Commissioner: The Ministry of the Environment is responsible for water quality in natural resources, and the Ministry of Health for the quality of drinking water; the Ministry of the Interior, local authorities, and a few other bodies have subsidiary roles (Gabbay, 1992) This structure not only reflects the strong linkage between agriculture and water, but also symbolizes the conviction that water policy is an essential, but subordinate, element of agricultural policy. The State Comptroller has been quite critical of the Water Commission for decisions which have contributed to the recent water crisis in the country. More recently, she has joined others in criticizing the Ministry of Agriculture for developing long-term plans for the country that ignore the severe water shortage.

The Water Commission has two main operational arms: Mekorot, the national water authority, and Tahal, the water planning company. Mekorot is a public corporation owned jointly by the government, the Jewish Agency and the National Federation of Labour (Histadrut). It owns and is responsible for the water supply infrastructure, including pumping stations, wells, irrigation projects, and the National Water Carrier. Tahal is a government corporation (although it was on the government's list to be privatized, a move that has been delayed under the Labour government, according to Moore (1993)) with responsibility for overall water planning, research and design. Both of these units must grant permission before any new wells are drilled in either Israel or the Occupied Palestinian Territories. Of the two, Mekorot is the stronger. It is formally accountable only to the Minister of Finance and can raise money independently. This creates a diffuse structure which manages the water system more through "friction" with one another than through cooperation (Galnoor, 1980).

Israel's water supply system is completed by an extensive transportation and distribution network. The main component of this system is the National Water Carrier, an integrated system of large-diameter pipes and reservoirs that carries water from Lake Kinneret to the central and southern regions of the country (see Figure 2). Completed in 1964, the Carrier, which has been described as a means of transferring the Jordan from a border to an internal river, can transport more than one million cubic metres (Mcm) per day from Lake Kinneret and distribute it to coastal areas and the Negev desert. The National Water Carrier carries almost 80 percent of Israel's surface water (supplemented by some pumping in the south) and provides access to water for almost all the country's people.

## Development and Diffusion of Irrigation Technology

In parallel with its development of a management scheme and institutional structure for water, Israel has made a great effort to develop and diffuse technologies appropriate for arid and semi-arid environments. For example, Israelis have extended geophysical techniques in the exploration for water and improved drilling methods to permit extraction of water from deeper aquifers. For the purposes of this study, it is more important to focus on end-use rather than production technologies, and of these the most important by far have been aimed at irrigation.

Irrigation is today a highly complex technique with many variations for different crops and different climates (Shady, 1989). Israel is a world leader in development of drip irrigation, which is a technique by which relatively small amounts of water are delivered directly to the roots of growing plants by means of perforated plastic piping (Gabbay, 1992). When fully developed so that the flow of water is controlled by sensors linked to central computers in large farms, efficiencies (that is, the proportion of water that reaches the roots) can reach 95 percent. Drip and other forms of micro-irrigation reduce water use by one-third or more, depending upon the crop. Despite high capital costs for installation ($1500 to $3000 per hectare (Postel, 1993)), nearly half of all irrigated land in Israel is now under micro-irrigation (Gabbay, 1992). Only Cyprus has a greater share of land under micro-irrigation, but actual acreage is only one-quarter of that in Israel.

In parallel with, and in part as a result of, the shift to capital-intensive irrigation methods, Israel has encouraged farmers to shift their planting toward crops that have higher unit values in the market, mainly fruits and vegetables. Water losses have been further reduced by older techniques such as lining canals to reduce leakage -- effective but again expensive (Shady, 1989).

Micro-irrigation techniques have the further advantage of reducing adverse environmental impacts typical of land under continuous irrigation. Notably, drip irrigation can avoid or reduce the salinization that tends to occur on irrigated land in an arid climate. Flood irrigation also leads to high levels of run-off. If Canadian data for the southern Prairies can be taken as an indication, three out of every four units flow back to water courses, but typically laden with pesticides, fertilizers and chemicals (Pearse et al, 1985). Despite drip irrigation, agricultural run-off remains a major environmental problem in Israel (see Section V.B.1).

Taken together, the efforts to increase the efficiency of water use in Israeli agriculture have been highly successful. Agricultural output has increased using the same amount, or even reduced volumes, of water (Heathcote, 1983; Hillel, 1991). Water consumption per hectare has declined from nearly 6400 cubic metres per hectare in 1975 to 4500 in the late 1980s. Over the same period of time the volume of water consumed per dollar of agricultural output has declined from 1.6 to 0.75 cubic metres (Fishelson, 1992).

Later sections will emphasize water in the Occupied Palestinian Territories. Suffice it here to say that Mekorot and Tahal do operate in the Territories, though mostly in cooperation with the military authorities and, to a minor extent, local Palestinian authorities (West Bank water companies collect water fees and administer certain of the rules). To allow for development and implementation of technical solutions to water problems in both the West Bank and the Gaza Strip, a significant financial investment would be required, and, for the most part, Israel refrains from such a commitment (Starr and Stoll, 1988).

Despite all of the investment in infrastructure, and the improvements in efficiency and the growth in use of recycled and saline water, water supply has not kept pace with demand, and the threat of water shortage persists. Population growth rates are close to 2 percent per year, and immigration could significantly increase population in both Israel and the Occupied Territories by the beginning of the next century. Because of this, Israel's water planning must now also attempt to address demand, and to reduce inefficient use.

# IV. WATER QUANTITY: THE ECONOMIC CRISIS

> The country is on the verge of a catastrophic water shortage after 25 years of irresponsible neglect of resources that represent the lifeblood of the nation, according to the report on the water economy issued yesterday by State Comptroller Miriam Ben Porat.
>
> (*The Jerusalem Post*, 3 January, 1991 p.1)

Prior to the 1967 War, water use in Israel had reached both physical and economic limits. The war greatly increased the nation's access to water, but, inasmuch as few people seemed to draw lessons from earlier experience, use patterns were maintained and the new sources also came to be used to -- and beyond -- their limits. Since the mid-1970s water use in Israel has been at or near 100 percent of the resource potential. According to the Israel Environment Bulletin (Spring 1991), consumption exceeds available capacity (the amount one can tap before "mining" occurs) by some 200 Mcm per year. Moreover, the deficit in the reservoir system (that is, the gap between current levels and what is considered a safe operational reserve) had reached 1430 Mcm by late 1991 (Ibid.). Adding to the dilemma are increasing standards of living (air conditioning etc.) and renewed immigration, on the one hand, and several successive years of low rainfall, on the other. As noted, the latest drought broke in the winter of 1991/92, completely recharging Lake Kinneret and increasing the level of the aquifers, but others will occur.

It is necessary to look at water as an economic problem from both short-term and long-term perspectives. The former deals with immediate costs and returns as seen by conventional economic accounts; the latter with the potential for significant population growth and for global change. Between these two, a few comments will be made about the implications for regional politics.

## EFFECTS ON THE ECONOMY

Almost 70 percent of the water Israel currently consumes is used for agriculture, which is very close to the world average (World Resources Institute, 1992). Many countries in the Middle East use more than 80 percent of their water supplies for irrigation. However, even a 70 percent share does seem disproportionate compared with agriculture's importance in the economy of Israel. Agricultural employment now accounts for less than 4 percent of the labour force (Table 4). Although output continues to climb (especially the tonnage of vegetables and citrus fruit), agriculture now contributes just 5.4 percent of Israel's export earnings (Table 4). It would appear that reductions in water use by the agricultural sector could alleviate water problems in Israel *with no or only a small economic cost.*

**TABLE 4. EXPORT EARNINGS AND EMPLOYMENT IN ISRAEL, SELECTED SECTORS, 1990**

| | Value of Exports | | Employment | |
|---|---|---|---|---|
| | Exports (US$ M) | % of Total | Employees (millions) | % of Total |
| Agriculture | 656.2 | 5.4 | 58.9 | 3.9 |
| Chemical and Oil Products | 1 449.7 | 12.0 | 18.6 | 1.2 |
| Metal Products | 691 | 5.7 | 46.0 | 3.0 |
| Electrical and Electronic Equipment | 1 637 | 13.6 | 43.8 | 2.9 |
| Transportation Equipment | 569.5 | 4.9 | 23.9 | 1.6 |
| All Others | 7 075.6 | 58.4 | 1 300.7 | 87.4 |
| **Total** | **12 079** | | **1 491.9** | |

*Source: Statistical Abstract of Israel, 1992.*

*Current Misallocation*

The evidence strongly suggests that Israel's water quantity crisis is more a result of misallocation than absolute scarcity. As many analysts have noted, a shift of water away from agriculture to urban and municipal uses, or even to less water-intensive crops, would enormously reduce or even eliminate problems of relative water scarcity. Rough calculations show that reduction in irrigated acreage by about one-third, together with modest improvements in end-use efficiency, would be sufficient to bring Israel's water consumption and renewable water supply into balance.

The problem in Israel, as in so many countries, is that farmers pay far less than the full cost of delivering irrigation water to them. Indeed, most farmers cannot afford to pay a very high price for water if the crop is to be sold profitably (Muller, 1985). Within the Green Line, farmers typically get water for agricultural use at $0.16 per cubic metre, compared with $0.40 for domestic use. Zarour and Isaac (1991) estimate that the actual cost to supply water in Israel is $0.36 per cubic metre (0.036 cents per litre). Other estimates are slightly lower, but none less than $0.30 per cubic metre. Urban dwellers, therefore, are paying full average costs (though not necessarily marginal costs), but farmers are highly subsidized. (Prices are the same for Arab and Jewish communities in Israel, but differ in the Occupied Palestinian Territories; more on this below.) Gideon Fishelson of Tel Aviv University (1992a) estimates that only about half of the water devoted to agriculture in Israel has a marginal value greater than its cost. He estimates that appropriate market pricing of water would transfer 300 Mcm from inefficient agricultural uses to non-agricultural uses, enough to support an additional two million people in Israel.

Even if the level of subsidy for water to farmers in Israel is modest by regional standards (Khouri, 1992), the low marginal economic productivity of water used in agriculture suggests strongly that some water should be reallocated from irrigating crops to industrial and household uses. Perhaps flowers and some fruits and vegetables exported fresh to Europe can pay the full cost of water, but not grains nor most food crops.

Water is expensive because even conventional water supply systems are capital intensive, especially per dollar of revenue (Rogers, 1988). According to the World Bank (cited in Starr, 1992), the Middle East/North Africa has the highest capital costs of water supply in the world. Operating costs are also high. Israel and Jordan each use about one-fifth of their electricity just to pump water. (In the case of Israel, most of that electricity is used to pump water up from Kinneret, which lies 209 metres below sea level, to the National Water Carrier.) If conventional systems are capital intensive, non-conventional supply alternatives are even more so, and, in the case of desalination, very much more so. As indicated above, so too are such techniques as installing drip irrigation, lining canals and eliminating leakage. About the only options that are not particularly capital intensive are those conservation measures that represent improved management and better housekeeping.

### *The Potential to Reallocate Water*

The emphasis on agriculture in Israel, and the subsidies agriculture receives, are well out of proportion to the sector's *economic* importance to the nation. A partial restructuring of the Israeli economy away from agriculture and toward light industry, services and information technologies would save not only water but energy as well. The contribution of the light industrial sector to GDP is almost 30 times greater per unit of water than the contribution of the agricultural sector (Naff, 1992). From these perspectives, the point so often raised -- that Israel is one of the world's most efficient users of irrigation water -- misses the main point.

The strongest attack on water use in agriculture in recent years has come from Miriam Ben Porat, the State Comptroller. She emphasized the misallocation problem and made explicit reference to the close linkage between the Water Commissioner and the Minister of Agriculture. She put most of the blame for the water crisis on low prices and poor management, which have stimulated demand for water and reduced incentives to conserve (Shuval, 1992). As the subsidized water is commonly used for export crops, the benefit is effectively passed on to foreign consumers. Thus, Baskin (1992) states ironically that it would be cheaper to import oranges from Europe than to grow them in Israel, and he goes on draw the corollary that exporting oranges is equivalent to exporting water. More formally, the State Comptroller charged that, in terms of contributing to the nation's economy, subsidized prices for irrigation water actually caused "recognizable economic damage." In making this point, she was merely adding her name to a list of consulting reports that date back at least 15 years and that make essentially the same point (Kneese, 1976). She also added her voice to earlier calls to remove water management from the Ministry of Agriculture and place it under an independent state authority that would make judgements on overall national priorities.

During the recent drought, pressure to reduce water allocations and subsidies to farmers became too great to resist. Water allocations to the agricultural sector have declined since 1986, at first by marginal volumes, but by 37 percent in 1990 and fully 50 percent in 1991 (Lowi, 1992). Statements made at the time promised that the lower levels would be in place for at least five years, but, after abnormally heavy rainfall in the winter of 1991/92 raised the level of Lake Kinneret with enough left over to recharge aquifers, water allocations to agriculture were again increased. However, it has been estimated that these rains provided Israel with only one year of additional supply.

Those reductions in water allocations to agriculture should have provided a great deal of information on the ways in which farmers adjust crops, cropping patterns and operations for lower water consumption. Unfortunately, a literature review commissioned by IDRC found no studies on how farmers and others actually did cope with reductions of this magnitude, particularly when they expected them to be permanent. Data do show that the land under drip irrigation declined by 18 percent, and total irrigated land by 15 percent, during the drought (Postel, 1993). Fishelson (1992a) reports that output was down by about one-third at the peak of the drought, but this figure compounds secular and cyclical effects and is too aggregate to be truly instructive. Detailed information on adjustment patterns, which is likely available in the Israeli Ministry of Agriculture, would be very useful in determining the timing and extent of water reallocation that could occur without causing undue hardship and economic loss for farmers who have, quite understandably, invested in infrastructure and developed management systems on the assumption that water would continue to be available in large volumes at low prices.

In the longer term, permanent reallocation of water away from agriculture -- whether directly, through reduced allocations, or indirectly, through marginal cost pricing -- is inevitable. This creates a dilemma for the nation. On the one hand, conversion to more efficient farming methods to reduce water demand could be expensive and, in effect, dilute the dominant role of the agricultural sector in Israel's politics and economy (Frey and Naff, 1985; Starr and Stoll, 1988). This role has a long history related to the Zionist ideology of a Jewish proletariat working (and therefore justifying possession of) the land, to national pride in "making the desert bloom," and to military security based on a domestic food supply.

On the other hand, agriculture is playing a smaller and smaller role in Israel's economy. This parallels international trends toward slower growth in irrigated agriculture, with most gains in production now expected to come from existing rather than new supplies of water (Postel, 1991; World Resources Institute, 1992). The eventual resolution appears to lie with the full substitution of reclaimed wastewater for freshwater in agriculture, provided: a) high enough standards are applied to the water; b) salt-tolerant, high-value crops are selected; and c) appropriate irrigation methods are used.

*Projections of Water Use*

Projections of future water use in Israel vary significantly. One set of projections implies steady growth in consumption to 2025 (Gabbay, 1992). According to Gabbay's (1992) report, which was a component of Israel's national report submitted to the Earth Summit in Brazil, the greatest absolute and relative growth in water consumption is projected for the agriculture sector. (Only the industrial sector shows no significant growth in water use.) These assumptions assume increasing availability of water in the region, a condition which is highly unlikely without major water-sharing agreements and importation of water. It is also a scenario which would be very costly to the Israeli economy. Fishelson (1992) projects similar increases in water consumption, with agricultural use increasing to 1800 Mcm per year by 2020, and urban use to 900 Mcm; the result would be a water deficit for Israel of between 800 and 1100 Mcm per year.

A rather different, and more realistic, set of projections has been prepared by Tahal as part of a water master plan. Although the Tahal projections show substantial growth in water use by the domestic and industrial sectors to the year 2000, agricultural consumption is expected to remain constant. (These projections refer to fresh water; brackish and recycled water are excluded.) Tahal's projections include Ministry of Agriculture plans to maintain agricultural water consumption at 1300 Mcm annually. These projections seem all the more reasonable since, in the wake of reduced allocations and higher prices, agricultural water consumption in 1991 fell below 1000 Mcm for the first time since the 1950s.

A different approach to the problem of projecting future requirements is suggested by Shuval (1992). He believes that peace depends upon "the principle of a sufficient, fair and equitable allocation of essential baseline water for domestic, urban, industrial and fresh food use, much of which would be from sources within the territory of each partner" (1992, p. 41). Shuval then suggests that the basic allocation for all uses except fresh food be 100 cubic metres per person-year and that another 25 cubic metres per person-year be allocated for growing fresh food. Other agriculture would depend upon recycled water. Based on these assumptions, he calculates "baseline needs [for fresh water] to assure water security" as in the following table.

**TABLE 5. POPULATION AND WATER CONSUMPTION PROJECTIONS UNDER A WATER-FOR-PEACE PLAN**

| | Population (millions) | | Water Use (million cubic metres per year) | |
|---|---|---|---|---|
| year | 2005 | 2020 | 2005 | 2020 |
| Palestinians | 3 | 5 | 375 | 625 |
| Israelis | 7 | 10 | 875 | 1 250 |

*Source: Shuval, 1992*

These demands for fresh water are much more modest than those usually projected. Although Shuval admits that they are attainable only if "coupled with sound measures of water conservation," they nevertheless provide a more manageable target, and one less threatening to either political or ecological stability.

Shuval's suggestion for a baseline security approach is intermediate between the use of projections and the use of scenarios in identifying possible water futures. The "soft water path," which is depends exclusively on scenarios, is described in Chapter VII with other aspects of planning.

### Implications for the Political Situation

The water supply situation in Israel is complicated by the fact that Israel currently draws about one-third of its total fresh water supplies, and 50 percent of its drinking water, from sources that originate from the West Bank. Most of that water continues to be drawn, as it was in the pre-1967 period, by wells within Israel proper. (The first boreholes were drilled by Jewish farmers in the 1930s.) That is, vertical wells are drilled within the Green Line to reach the Mountain Aquifer and bring water to the surface for irrigation and other uses. Israel draws between 300 and 350 Mcm per year from these wells, which is about half of what the aquifers can supply on a fully renewable basis. Such wells are consistent with international law, but, as will be discussed later, some of the provisions applied on the Palestinian side of the Green Line to ensure maximum flow into the aquifers are of questionable legality and morality.

Without any question, Israel would face immediate water shortages and significant curtailment of its economic development if it lost control of West Bank water resources supplies in a sudden or disruptive manner. The state is trapped in what Calleigh (1983) refers to as the "hydraulic imperative". The West Bank, then, has become a critical source of water for Israel, and this fact may actually be outweighing other political and strategic factors in its continued occupation (Anderson, 1988).

The same steps outlined above to rationalize the economy's use of water could also reduce or eliminate the need for Israel to transfer water from the West Bank for consumption elsewhere in the country. To now, Israel has clearly given priority to its own water needs at the expense of those of the Palestinians. Reductions in water allocated to Israeli agriculture could be coupled with increases to the Occupied Palestinian Territories. Such action is indicated as much by economics as by justice. The West Bank remains far more rural than is Israel, with agriculture accounting for more than a quarter of its employment and of its gross domestic output (Baskin, 1992). Ironically, then, while Israel needs to transfer water out of agriculture, Palestinians need to transfer water in -- but the latter is feasible only if they have access to a greater share of both surface and underground water.

## End-Use Conservation

With the exception of the agricultural sector, nations in the Middle East are remarkably sparing in their water use. For centuries, the peoples of the desert have learned how to make use of every drop. Per capita withdrawals in Israel are only about 25 percent, and in Jordan only about 17 percent, of those in the United States or Canada. Nevertheless, all of the countries in the region are using much more water than they need to, and enormous potential exists to increase efficiency in the use of water and to stimulate greater conservation.[3] The problem, to quote Thomas Naff, is not that these nations are inefficient but "that they are not as efficient as the crisis and the scarcity requires them to be" (Naff, 1990, p. 170).

The need to reallocate water was discussed just above. This section will demonstrate that, even in the absence of reallocation, there are many policies and programs that could be implemented to promote greater efficiency and conservation in water use. They will be discussed under subheadings of improved price structures and then conservation in, respectively, residential uses, commercial and industrial uses, and municipal systems. These sections barely introduce a subject with an extensive literature. Because it has been discussed above, irrigation will not be treated here. Apart from

[3]"Efficiency" and "conservation" are commonly used synonymously, but, strictly speaking, the former refers to minimizing inputs to achieve a given output whereas the latter includes changes in the output. Less formally, efficiency deals with how you accomplish some task, while conservation also includes changes in the task.

irrigation, farms consist of households (analogous to residential uses) and processing plants (analogous to industrial operations). Clearly the opportunity for conservation is large. Water efficiency in Israel lags behind best achievable practices except in irrigation. However, except for changes in prices and price structures, none of the measures discussed below will be very effective if governments at all levels do not insist -- insist very vocally -- on higher levels of water conservation and water efficiency, and if they do not demonstrate their resolve by highly visible conservation in their own operations.

### *Alternative Price Structures for Water*

Since water is one of the highest value inputs to the Israeli economy, it should be priced accordingly. This means a number of things. Most obviously, those who use water should pay the full costs, capital as well as operating, to extract, treat as necessary and deliver water. Less obviously, price structures should reflect what economists call long-run incremental or marginal costs, which is the cost of supplying the last unit of water demanded. In this way users will be forced to recognize the costs their demands impose on the water delivery system. When the system is operating correctly, the same principles mean that prices will also reflect opportunity costs, or the value of water in alternative uses. While an exception to full opportunity cost pricing may be made on grounds of equity for direct household consumption (analogous to lifeline rates for electricity), the quantities needed to provide everyone with enough water for basic needs are so small relative to other uses as to make little difference to final results.

The same principles that argue for pricing of water as an input also argue for charges for disposal of wastewater. Appropriate charges would vary by volume and toxicity of discharge -- with some credit offered for those wastes, such as sewage, that themselves have a value. As with water, the objective is to ensure that households, industrial firms, and farms take account of the costs their operations impose on the system. Unfortunately, charges cannot be applied very effectively to non-point sources of wastewater, as with runoff from farms.

The rationale for pricing water in a way that reflects its true costs has been expressed in many reports and is supported by a great deal of evidence (Pearse et al, 1985; Brooks et al, 1990; Postel, 1993). The essential point is that, beyond the amounts needed for basic human and household needs, water demand is elastic, and notably so in the case of irrigation.[4] If water is cheap, more will be used; if it is expensive, less will be used. If discharge is cheap (or unregulated), wastewater flows will be high; if expensive, flows will be reduced. Neglect of the elasticity of water demand in current pricing structures makes the whole water system inherently inefficient from an economic perspective. The low prices create excessive demand for water supply or discharge; force up government expenditures to provide infrastructure to meet this demand; and inhibit efforts for conservation and recycling.

Pearse et al (1985) emphasize that an ideal pricing system for water includes two elements: one element is a charge per cubic metre consumed; the other is a fixed charge per month. The fixed charge covers hook-up costs and other overhead needed to operate the system. The charge per unit can be set in many ways but ideally equals the marginal cost of water supply. Assuming increasing costs of supply, which is the case throughout the Middle East, most economists would favour a price structure in which unit charges for water increase with consumption, commonly referred to as increasing block rates (Brooks et al, 1990). While not necessarily appropriate for lower income communities where households have to share water taps (Whittington, 1992), as in parts of the Gaza Strip, increasing block rates would certainly be appropriate for all users in Israel and many users in the cities of the West Bank. The price structure can be made to reflect marginal costs even more closely by increasing prices during the summer when demands tend to peak and supplies come from more limited and expensive sources. Alternatively, charges could be reduced for users who can use water at off-peak periods or who can accept lower quality water that requires less treatment.

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[4]Elasticity is a measure of the effect of price changes on the amount of any good or service purchased. The good or service (in this case, water) is said to have an elastic demand if the change in quantity purchased is proportionately greater than the change in price; it is inelastic if the change in quantity purchased is proportionately less.

Any approach to efficient price structures for water requires that meters to measure water volume, and other meters to measure at least the volume of wastewater, be installed at every billing point. Fortunately, water meters are ubiquitous in Israel. They are found on a unit-by-unit basis within apartment buildings and (for control if not billing purposes) on a process-by-process basis within some industrial plants. Farms are also metered for water use, but the low prices for water mitigates the effect. Wastewater meters are less common, and charges for wastewater disposal are only now being considered.

No matter how well designed the price structure, and even if price levels are set high enough to cover all costs, supplemental policies and programs will be necessary to capture the full range of conservation and efficiency options. The supplemental measures are necessary in part because of market failures, in part because of lack of information on or capital to pay for conservation measures, and in part because the market system is only one of the signals to which consumers respond (Brooks et al, 1990). The most common supplemental measures include information services, technical assistance, and financial incentives or disincentives.

*Conservation in Residential Uses*

Residential uses of water tend to be less price elastic than other uses, partly because these uses are essential for life and partly because (except for the poorest people in developing countries) water does not account for a very large part of household budgets. The major uses for water in housing with internal plumbing are toilet flushing, clothes washing, and showers/baths. (Again excepting the poorest of the poor, water for drinking and cooking is all but negligible.) None of these end-uses is individually large compared with agricultural or industrial use of water, but significant overall gains are attainable from simple technologies and minor changes in habits, even with housing that is already efficient (Brooks and Peters, 1988). For example, low-flow household faucets cut use to 0.5 litres per minute without sacrificing performance, a saving of up to 85 percent; low- and variable-flow toilets can cut water use by 40 percent. (These savings are based on comparisons in North America; savings would be lower in Israel because of higher existing standards of water efficiency.) If hot water is saved, the gains are multiplied:

energy as well as water. For those housing units with external space, lawn and garden watering typically dominates total water use, but is more responsive to price than other uses (Brooks et al, 1990). Total residential savings (again on a North American base) with existing technology is one-third to one-half, with the higher levels applying to hot water.

Market failure from misplaced incentives is common in the residential sector. For example, firms or agencies building housing units do not in general continue to own or manage them. Given market and political pressures to build at low unit cost, they will not likely include more water-efficient plumbing if it is significantly more expensive. Therefore, housing is the sector where regulations for minimum efficiency standards in water-using equipment are most appropriate. In the case of Israel, with the pressure to build housing for newly arriving immigrants, the need for regulation is that much greater.

If the experience with energy can be taken as a model, regulations not only change purchase patterns but stimulate manufacturing research so that the equipment available is improved over time. This impact is enhanced if only end-use efficiency is mandated (eg, water flow per minute or per flush) and manufacturers are left free to determine how best to achieve that level. Regulation is usually most effective if coupled with information programs for every part of the market: producers, designers, builders, financiers and residents. Other measures can also be considered, as with design awards.

Special forms of government intervention are required to stimulate improvements in the water efficiency of existing housing, which is large and typically well behind state-of-the-art techniques. As a rule, it is more expensive to retrofit existing systems than to build new ones. In this case, regulation can help by insisting on changes at the time property is sold, and information programs can stimulate building owners to install some of the less costly measures themselves. Some form of financial incentive for conversion to more water-efficient systems may also be appropriate for existing housing. Even then, total potential savings are only about two-thirds as great as with new housing (Brooks and Peters, 1988).

*Conservation in Commercial and Industrial Uses*

Commercial and industrial use is heavily concentrated in a few sectors, and each sector is significantly responsive to price signals. Office and retail buildings generally have relatively low levels of water use, but restaurants, hotels, and certain commercial establishments, such as laundries, can use a great deal of water, much of it hot. Most of the technologies appropriate for residences are equally appropriate for the hospitality industry, and others, such as self-closing valves, can be added. In North America, savings of 10 to 25 percent have typically been obtained simply by better management and very low-cost adjustments to the system. Savings of up to 50 percent have been achieved with more substantial retrofits, such as dual water systems (one for fresh and one for recycled water (Okun, 1991)), that have paybacks of a year or less at current water prices. It is not possible to estimate what the savings might be in Israel, but even casual observations indicates wide differences in water efficiency at different hotels.

Industrial use of water varies widely both between and within sectors. The largest single industrial user of water is for cooling, but this is largely nonconsumptive; after use, the water is recirculated or returned to the river, warmer but otherwise unaltered. Among manufacturing industries of importance in Israel, the food and beverage sector and the chemical, petrochemical and refinery sector are large water users, though both undertake a great deal of recirculation so as to minimize total water requirements. (They are, however, less careful about wastewater discharges.) Again, in the absence of sector-specific information about output and water use, it is difficult to say much about potential savings. Such techniques as process metering, mapping of pipes, timers, pressure reductions, and heat recovery (to eliminate the need for cooling water), but not including recirculation or process change, have yielded savings of 30 to 50 percent; if recirculation and process change are included, savings have reached 90 percent (Brooks and Peters, 1988; Postel, 1993). While higher savings could be expected when starting from the water-inefficient plants in North America than with the relatively water-efficient ones in Israel, it must also be remembered that the required investments were determined to be cost effective at prices well under those in Israel. Japan, not particularly water rich, has cut its industrial water use by nearly one-fourth, and increased its output per litre by 3-1/2 times, in the last 25 years (Postel, 1993).

Except for large buildings, where policies and programs similar to those for residential uses are appropriate, it is difficult to generalize about policies appropriate to commercial and industrial uses. Each sector needs to be studied on its own. The one thing that is clear is that higher prices and more carefully designed price schedules will have a strong effect. The effect will be even stronger if supplemented with information and possibly low-cost financing aimed at smaller industrial and commercial establishments. Owners typically lack both information and of capital, and they may not even know how they are using water, nor to what extent they are degrading its quality. A program to provide water (and energy) audits at cost might prove highly effective.

*Conservation in Municipal Systems*

Municipal use of water includes a great variety of end-uses, such as fighting fires, cleaning, irrigating parks, public swimming pools, etc. Opportunities for conservation and use of recycled water are evident. However, the most important aspect of the municipal system is the system itself: reducing pressure, valve maintenance, and, above all, repair of leaks. Losses of 10 to 15 percent of the water in municipal systems is quite common. With older systems, and in the cities of developing countries, including those of the Occupied Palestinian Territories, losses commonly exceed 50 percent. In effect, the water supply system is either twice as large as need be or it could serve twice as many people. Identification and repair of leaks in the water distribution system is not cheap, but it is generally one of the most cost-effective ways of increasing the supply of water.

There is little point in talking about policies for municipal systems. For the most part, all of the necessary tools are within the control of city officials. Senior levels of government can, of course, help by providing technical and, probably most important, financial assistance. Once an effort is made, savings can come quickly. Jerusalem cut its water use by 14 percent between 1989 and 1991 through a combination of water-saving devices, leak repair, and more efficient irrigation of city parks (Postel, 1993).

## LONGER TERM PROSPECTS FOR CHANGES IN WATER BALANCES

Water scarcity in Israel becomes more acute when one considers demand and supply in the context of future socio-economic and ecological changes that may occur. The socio-economic factor with the greatest potential impact is population growth; the ecological factor is global climate change.

### *Demographic Change*

Israel's current population is approaching 4.5 million persons; population growth is 1.6 percent per year in Israel, and the government maintains a pro-natalist policy. Immigration of Soviet and Ethiopian Jews to Israel will likely increase the population over the next few years, if not the natural growth rate.

The Palestinian population of the West Bank (including East Jerusalem) and Gaza is about 1.7 million (Heller and Nusseibah, 1991). The rate of population growth is close to 3 percent per year. A Palestinian state on the West Bank could draw back an additional 750,000 to 1 million people (Ibid.), most of them from refugee camps (which currently house close to 800,000 Palestinians in the West Bank and Gaza, Jordan, Lebanon and Syria). The numbers could increase with new conflicts within the Arab world, which provides a home for much of the Palestinian diaspora.

Finally, to complete the picture, although Jordan and Syria are relatively lightly populated at present, growth rates of 3.8 percent are reported from both countries. Even present levels of population strain the available resources (in Jordan) or the existing infrastructure (in Syria). Population growth can only increase pressure on water (and other) resources. The results of these rates of population growth are shown in Table 6.

Combining these rates of population growth with projections that assume no changes in water policies, technologies or consumption patterns yield truly frightening deficits. By 2020, the existing Israeli water deficit of 200 to 250 Mcm per year could grow to around 500 Mcm per year in the absence of immigration and to twice that figure if one assumes an additional one million immigrants (Fishelson, 1992). Palestinian immigration and natural population growth would, under these assumptions, approximately double the current water deficit in the Occupied Palestinian Territories of 100 Mcm per

**TABLE 6. POPULATION DATA, SELECTED MIDDLE EAST COUNTRIES, ACTUAL 1960 - 1990, AND PROJECTED TO 2025**

| | Population Size (millions of persons) | | | | | | |
|---|---|---|---|---|---|---|---|
| | 1960 | 1970 | 1980 | 1990 | 1995 | 2005 | 2025 |
| Israel | 2.1 | 3.0 | 3.9 | 4.8 | 4.9 | 6.3 | 6.9 |
| Jordan | 1.7 | 2.3 | 3.2 | 4.2 | 4.7 | | 9.9 |
| Lebanon | 1.9 | 2.5 | 2.7 | 2.9 | 3.0 | | 4.7 |
| Syria | 4.6 | 6.3 | 9.0 | 12.3 | 15.0 | | 34.1 |

*Sources:* *World Tables, 3rd edition, 1983; World Resources, 1988-89; Statistical Abstract of Israel, 1992; Fishelson, 1992b.*

year. (There is a discrepency in the data on water availability in the West Bank. Some authors characterize the situation as a water deficit, while others claim there is no deficit. Unquestionably, there is a distributional problem, as water is not supplied to over 20 percent of West Bank Palestinian settlements.)

In addition to internal deficits, problems of water supply and demand in Israel must be placed within the broader regional context. Jordan, with annual rates of per capita consumption already 25 percent below the generally accepted "water poverty line" of 100 litres per capita-day, is projecting a water deficit of 350 Mcm per year or two to two-and-a-half times this amount based on its rate of population growth and immigration. Syria and Lebanon are the only countries that could continue to expand water use for some time in measure with population and economic growth, though both countries already face local shortages in urban areas.

Deficits of the size and duration suggested above are not sustainable and possibly could not be supported except in an occasional year of high rainfall. The projections should not be treated as predictions, however. Their main value is to emphasize the impossibility of a business-as-usual scenario and, by implication, the need for changes in all three: policies, technologies, and consumption patterns.

*Global Climate Change*

Magnifying demographic pressures on the water system is the spectre of global climate change that could reduce the amount of water available to the region's rapidly growing population. Anthropogenic emissions of certain gases, most notably carbon dioxide ($CO_2$), methane ($CH_4$), chloroflourocarbons (CFCs), nitrous oxides ($NO_x$) and water vapour, all contribute to a general process known as the "greenhouse effect," or global warming. The term "greenhouse gas" has been applied to atmospheric gases that are relatively transparent to incoming short wave solar radiation but which absorb the long wave radiation from the surface of the earth and re-emit it downward, warming the surface of the earth and the lower atmosphere. Emissions of these gases are increasing at a constant rate, primarily as a result of increased fossil fuel combustion. The focus to date has been on $CO_2$, released from the burning of coal and other carbon-based fuels and from the burning and decay of the world's forests. Since 1958, when measurements of $CO_2$ in the atmosphere began, its concentration has increased from 315 to 353 parts per million (ppm). A doubling of $CO_2$ from pre-industrial levels -- expected sometime next century -- could result in global temperature increases on the order of 1.5 to 4.5 degrees Celsius (and much greater in the high latitude zones of the northern hemisphere). Concentrations of the other greenhouse gases, currently at much lower concentrations than $CO_2$, but more potent in their ability to promote heating and thus potentially more damaging, are increasing even more rapidly. $CH_4$, which is emitted from wetlands, rice paddies, livestock and from warming permafrost is increasing at the rate of 1 percent per year (compared with 0.4 percent per year for carbon dioxide). CFCs have been increasing at 5 percent per year, although with the Montreal Protocol, which set international limits on the emissions of CFCs, concentrations of this gas should decrease over the next two decades.

Climate warming, if it occurred, would affect the water supply situation in Israel in three ways (Lonergan and Kavanagh, 1991; Hillel, 1992). First, temperature in the region would likely increase between 15 percent and 30 percent over present levels. This would increase evaporation rates (by 5 to 20 percent), increase the amount of energy needed for space cooling (which would prompt a demand for more electrical generation, although not, necessarily, affect water demand or supply directly), and likely increase the demand for domestic consumption for drinking water and recreational uses. More importantly, precipitation would likely decline (although the climate models are not consistent in their precipitation projections for the region). This would have obvious implications for the amount of water supplied to replenish streams and recharge aquifers. And, third, the *variability* of precipitation might change, resulting in longer and more severe droughts, and exacerbating the problems already experienced with a highly variable hydrological cycle.

## SUMMARY

Water quantity problems in Israel are not so much ecological as economic in origin: from a supply perspective, there is plenty of water available provided you can pay for it; from a demand perspective, the cheaper water is, the more abundantly and wastefully it will be used. By common agreement, the core of the problem in Israel is misallocation of water. Most people, and particularly farmers, pay too little for water. As a result, water conservation is more a slogan than the imperative it should be. These facts and their connection to declining water availability are becoming more widely known, and the time is likely not far in the future when permanent reallocation of water and new pricing structures for water will be instituted in Israel -- which is not to say that either will be accomplished without spilling a great deal of political blood and insistence on change from the public.

A search for reasonable solutions to the water problems in the Middle East, whether unilateral, bilateral or multilateral, must take into consideration the dynamic nature of the social and environmental systems present. Very high rates of natural population increase, coupled with significant immigration, will further strain the water supply system of all countries in the region. Without basin-wide solutions to water problems, the level of population growth is not sustainable. To exacerbate the problem, there is a possibility that *less* water will be available in the future, through a combination of increased variability in precipitation and higher rates of evaporation. Climatologists now believe there will be a greater magnitude and frequency of "extreme events" accompanying climate warming, which suggests longer and more severe droughts for the region.

# V. WATER QUALITY: THE ECOLOGICAL CRISIS

Waters wear the stones.

(Job 14.19)

The second component of Israel's water crisis is less ancient but equally pressing: water quality. This component is part of a growing environmental problem that has been described as a "sharpening struggle" by Brooks and Shadur (1991). Water quality problems are a compound of many factors, three of which deserve to be highlighted: overpumping of aquifers, pollution of water courses, and the limited size and protection of ecological preserves.

### Overpumping of Aquifers

Overpumping of wells causes a decline in the water table. During the recent drought, when aquifers were pumped particularly hard, water levels in aquifers in Israel and the Occupied Palestinian Territories were typically falling by 10 to 40 centimetres per year, a situation that everyone recognized to be unsustainable.

A decline in the water table has several adverse effects. At a minimum, it adds to pumping costs and increases energy consumption for pumping. More importantly, a lower water table reduces pressure in the aquifer and permits lower quality water to flow inward and contaminate the fresh water of the aquifer. The Coastal Aquifer in its natural state is 3 to 5 metres above sea level, which, thanks to the force of gravity, creates an outward pressure that blocks the inflow of seawater. Pumping, or more accurately over-pumping, has lowered the fresh water level below sea level so the effect is reversed and salt water from the Mediterranean can now be found one to three kilometres inland. (Note that this situation changed recently with very heavy precipitation; it is believed, however, that this is temporary.) This inflow magnifies the effects of using and re-using water for irrigation with the result that 10 percent of the wells tapping the Coastal Aquifer now produce water too salty for domestic use, and Israel's Hydrological Service estimates that one-fifth of the wells will soon be too salty even for agricultural irrigation (Gabbay, 1992). If World Health Organization standards for drinking water were observed in Israel, many of the coastal wells would be unfit as sources of drinking water (Israel Environment Bulletin, Spring 1991). Worse yet, intruding salty water corrodes the limy portions of the porous sandstones that make up the aquifer, so that they become blocked and are reduced in capacity or even destroyed.

In the case of the Mountain Aquifer, which is the main source of drinking water for Israel, the problem is not seawater but nearby saline aquifers that can seep into the overpumped zones. Each of its zones contains some brackish water. Because it is composed of channels in limestone ("karst" structures), water (and pollutants) flow more quickly through the Mountain Aquifer than through sandstone aquifers with small pores. The Ministry of the Environment has proposed that a Mountain Aquifer Authority be established along the lines of the Kinneret Authority, but the response to date has been evasive.

## WATER POLLUTION

Israelis have made a good start at controlling air pollution, mainly because it was no one's responsibility, and the Ministry of the Environment (until 1988 the Environmental Protection Service) was able to assert control (Whitman, 1988). Not so with water, where the Ministries of Agriculture, of Industry, of Health and of the Interior are conspicuous by their support for vested interests and their lack of enthusiasm for defense of water quality. Dumping is common, sometimes directly into water courses and sometimes into wadis which, at the next rainfall, allow contaminants to seep into the aquifers. Cleaning a polluted river is difficult; cleaning a polluted aquifer is infinitely more so and in some cases simply not possible (Goldenberg and Melloul, 1992). Only in late 1991 were some of the jurisdictional issues over water resolved with the Ministry of the Environment receiving responsibility for toxic and hazardous substances, pest control, and prevention of nuisances.

Among Israel's major water pollution problems are the following:

*Agricultural Run-off*

Agricultural run-off is the major non-point source of many pollutants, including sediment, phosphorous, nitrogen and pesticides. Per hectare use of pesticides and fertilizer in Israel rates among the highest in the world, and run-off is correspondingly high. To date regulations on pesticide use are quite lax and all but non-existent on agricultural run-off. Even some irrigation water, for which standards can be well below those of drinking water, is now so contaminated with residues as to be unfit for use. For example, over the past two decades, nitrate concentrations in the Coastal Aquifer (from both fertilizers and re-use of sewage effluents) have doubled (Gabbay, 1992). Such problems are anything but inevitable. Practices such as conservation tillage, contour planting, terracing and filter systems, among others, can control soil erosion and reduce phosphorous and nitrogen run-off by up to 60 percent (World Resources Institute, 1992).

Pesticide residues are a special problem. There are no standards for permissible levels of pesticides in drinking water (and only lightly enforced ones for food consumed domestically; very different from food destined for export). Such tests as are made are held confidential and are not always made available to the public (Fletcher, 1991). Only occasionally do stories break into the news, as when the Ministry of the Environment made public its discovery that pesticides were being stored in water pumping stations.

The growing use of brackish water can increase soil salinity, a problem that is already evident in certain parts of the country (Gabbay, 1992). Washing out the salts with fresh water can alleviate local problems but at the expense of allowing the salts to drain into watercourses or aquifers with potential longer term problems. Regulations have yet to be developed to deal with this problem (except for limitations on use of brackish water just above sensitive parts of the Coastal Aquifer).

*Drinking Water and Sewage*

Piped drinking water and sewer systems are extensive throughout Israel, as is piped water in much of the Occupied Palestinian Territories. (Most of the water and sewage system in the refugee camps has been financed by United Nations agencies.) Today, 90 percent of municipal wastewater within Israel is collected in sewers, and 80 percent is treated (Whitman, 1988). However, just as with many cities in North America, the system has begun to deteriorate. The Health Ministry tests extensively for bacteriological contamination, and quality standards for drinking water were tightened in 1989. A small percentage of tests show excess contaminants, mainly because of antiquated and leaking sewage pipes in the northern part of the country. Older systems are being replaced, but progress is slow because of budget constraints.

Not surprisingly, Israeli investment in water supply is concentrated within the Green Line. Mekorot has connected towns and larger villages close to the Green Line and within the Gaza Strip to the National Water Carrier (Bruins et al, 1991). Nevertheless, drinking water quality is generally poorer on the West Bank and significantly so in the Gaza Strip where many residents routinely drink contaminated and/or saline water (Zarour and Isaac, 1991; Shawwa, 1992). Some 20 percent of West Bank villages still have no regular water supply (al-Khatib, 1992), and many residents are experiencing health problems because of inadequate (or non-existent) sewage disposal. Israel has extended water supply lines to cover about 60 percent of the households of the West Bank and is now beginning to extend sewage lines (Sbeih, 1992). For example, a sewage project is being built to serve Bethlehem, Beit Sahour and Beit Jala in the West Bank (Zarour and Isaac, 1991). However, the new sewage projects come with a trade-off: Israel gets the sewage which it then reclaims for its own use. The same wastewater could make a much greater addition to output if directed to Palestinian farms, which are short of irrigation water (Ibid.) but which cannot generally afford to install the capital-intensive irrigation techniques that characterize Israeli agriculture.

As noted in Section III.C.1, some 70 percent of municipal sewage in Israel is recycled as irrigation water. This is critical to Israel's water balance. However, re-use of sewage has its own problems; two-thirds of the re-used water receives minimal or no treatment, and much of it contains excessive quantities of chemicals (Israel Environment Bulletin, Spring 1991; Gabbay, 1992). This creates problems for farm workers and, in some cases, for the crops.

*Chemicals*

No one knows how badly contaminated Israeli surface and underground water is because so few tests are done (Fletcher and Nordell, 1991). Spot checks have found concentrations of specific contaminants at levels that are a few to 100 times the allowable levels in other industrial countries (Muszkat, 1989, cited in Fletcher and Nordell, 1991). Solvents, petro-chemicals, gasoline products and other wastes (some of them known or suspected carcinogens) are routinely dumped by municipalities and industries into any nearby water course. For example, the Kishon River in Haifa receives 10 thousand cubic metres daily of industrial waste water -- so much that parks along its banks are considered dangerous to health (Hirschberg, 1991). Olive oil mills, an otherwise excellent way to increase the value added from farming and provide employment in rural areas, have both solid and liquid residues. The former can generally be put back on fields, but the latter has so high a BOD[5] that it is generally just dumped. No data on the extent of this problem have been found for Israel, but the impact of some 40 mills in Jordan is equal to that of a city of one million. Contamination by heavy metals and synthetic organic chemicals is still reported to be low and limited to industrial areas, but more serious problems are expected in the future (Gabbay, 1992).

The Health Ministry is just now considering whether to establish standards on maximum levels of organic and inorganic compounds ("micro-pollutants") in drinking water. The Environment Ministry has proposed regulations to deal with industrial dumping and is moving to establish new regulations to deal with toxics. Still, Israel is a long way from "polluter pays" principle. And the country's one official toxic waste disposal site (Ramat Hovav) is

[5]BOD stands for biological oxygen demand, which is an indication of the oxidizing power of the waste stream. Liquid wastes with a high BOD draw all the oxygen from water so that other forms of life, both animal and vegetal, suffocate. Information about BOD content appears in written communications from the Royal Scientific Society in Jordan to IDRC in Ottawa.

so poorly designed and so limited in capacity that disposal pools overflow after heavy rains and contaminate nearby reservoirs (Whitman, 1988). Worse yet, evidence suggests that toxic wastes have been seeping downward into the aquifers that are vital to Israel.

## NATURE RESERVES

While Israel has a higher proportion of her land (about 18 percent) in national parks and nature reserves than most other countries, the protected areas are inevitably quite small. Fresh water areas come under intense pressure, particularly during the hot summer months, from both domestic recreational use and international tourism. They are also subject to encroachment, as when an industrial park was proposed close to Kabri Springs (a plan that was blocked by legal action).

Moreover, in its effort to assure adequate and growing supplies of water, Israel has regularly violated its usual concern with protection of nature and the Biblical landscape (Brooks and Shadur, 1991). Waste now contaminates many beaches, and those near Herzliyyah and Netanyah, among others, are regularly closed to bathers during the summer. Flow in the Jordan River has been reduced to a fraction of its former volume. And there is a plan to dam (albeit for electricity rather than, directly, for water) the last free-flowing stretch of the Jordan River (World Rivers Review, 1991). Ironically, the plan is being advocated by a kibbutz.

Despite these problems, nature preservation remains highly valued in Israeli politics. Growing recognition of the economic potential of eco-tourism adds to the forces against encroachment. (For example, because of its location at the junction of three continents, Israel is a funnel for tens of millions of birds that migrate south in the fall and north in the spring. Thousands of bird-watchers come to view the storks, pelicans, raptors and other species.) Israeli courts are increasingly open to legal arguments in favour of maintaining existing states of preservation, if not always to those for extending protection to new areas. What still appears to be missing is widespread acceptance of the ecological services of natural areas in protecting the quantity and quality of water outside the reserves.

## Some Hopeful Signs

There are exceptions to the generally dismal picture of water quality in Israel. Lake Kinneret (the Sea of Galilee) has been under a unified management plan that prohibits dumping and restricts uses of water from the lake. As a result, Kinneret retains its quality, and its beauty. The power of Mekorot is such that it could impose similar restrictions on other areas of the country, but that would run head-on into vested interests. Even Kinneret is not fully protected from agriculture runoff, with one result that nitrogen content in the water, and thus algae, has been rising.

Another potential exception involves the Yarkon River, which flows through Tel Aviv, Israel's biggest city. Coastal rivers are the most seriously degraded ecosystems in Israel. The Yarkon is typical. Only 27 kilometres long, its flow is greatly reduced because the springs which fed it have been diverted to the National Water Carrier. As a result, industrial wastewater and urban run-off are no longer flushed away. Now the Yarkon will serve as the test case of both physical and economic feasibility of reversing this situation. In late 1988, a special authority was set up to undertake remedial activities and restore the river to a condition that would permit recreational use. So far efforts have been mainly directed to clean-up of trash and debris, and restrictions on new dumping. It is too early to tell if the project will be successful and can be extended to other coastal rivers.

## SUMMARY

There is growing public demand in Israel for a reduction in water pollution. Israel has always had strong and widely respected non-government organizations in the environmental field -- most notably, the Society for the Preservation of Nature in Israel (better known simply as SPNI) -- and their work has been critical. However, the demand is much bigger than those groups alone. Concerns related to health, to preservation of limited recreational opportunities, and to the continuing image of a people tied to the land all play a role. Equally, some of the early efforts to reshape the land are now recognized as errors. Parts of the Hula may be restored to a wetland in order to protect Kinneret and prevent the spread of slow-burning fires that ignite spontaneously in the underlying peat as it dries and oxidizes.

Difficult issues remain, as much in cleaning up older problems as in coping with new ones -- and in responding to demands to cut corners in order to, for example, mitigate housing problems or create jobs for new immigrants. Nevertheless, there are grounds to think that Israel may have turned the corner in terms of recognizing that water has a quality as well as a quantity dimension.

# VI. DISTRIBUTION OF WATER: THE GEOPOLITICAL CRISIS

> More and more we learn (or do we?) that liberties, security and well-being can only be founded on well used lands, whose productivity is safeguarded and improved from year to year and generations to generations. But social justice... must also prevail. For injustices to farmers and peasants have in many times and places brought about the decay and decline of agriculture and with them social unrest.
>
> (W.C. Lowdermilk, Introduction to Reifenberg, 1955)

Water has been integral to local and regional politics in the Middle East for centuries. So far as Israel is concerned, water was recognized by the early Zionists to be critical to the success of their dreams (references cited in Lowi, 1992, p. 39; see also Hosh and Isaac, 1992, for more recent history). Few if any of these statements are relevant to present concerns. A better idea of the importance of water to modern Israel can be taken from an incident related by Heller and Nusseibah (1991):

> So frightening was the spectre of future water diversion that in the mid-1970s a Labour government generally opposed to Jewish settlement in the West Bank nevertheless decided to establish a small number of settlements in Samaria, a few kilometres east of the Green Line, in order to forestall the possibility that the initial catchments of the western aquifer would be turned over to foreign control (p. 108).

## Water Politics from 1948 to 1967

Prior to the 1967 War, Israel and the neighbouring Arab states had occasionally feuded over access to Jordan River waters. Naff and Matson (1984) documented a dozen water-related ceasefire violations in the Jordan River basin between 1951 and 1967 alone. On the other hand, each of the states more or less accepted the shares of water defined for them by the Johnston Plan in 1955 (see further below). The status quo appeared to be tacitly acceptable.

Although the authors of this document do not prescribe to this view, some analysts have speculated that the need for more water was a major factor in Israel's involvement in the 1967 War. A similar accusation has been made for Israel's incursion into Lebanon in 1982. Studies of the history of water and politics in the region are mixed on support for this contention (cf. Naff and Matson, 1984; Wolf, 1992; Wolf and Lonergan, 1993). Perhaps the most sensible statement appears in Heller and Nusseibah (1991, p. 107): "The development of Israel's National Water Carrier and Syrian attempts to divert headwaters of the Jordan River played a part in the chain of events leading to the Arab-Israeli war of 1967."

It is true that, at the time, Israel was tapping all of its available fresh water supplies and taking more than its share of Jordan River water. During the war, Israeli planes destroyed a half-completed dam on the Yarmuk River between Syria and Jordan, and also the intake facilities for the East Ghor Canal along the Jordanian side of Jordan River valley. These structures would reduce (or would have reduced) flow to either the Upper or Lower Jordan Rivers and thus the water available for use in Israel. However, whether these attacks were part of a considered plans or targets of opportunity chosen in the midst of a war is unclear.

## Water Politics After 1967

Occupation by Israel of the West Bank and the Golan Heights after the 1967 War significantly changed the dimensions of water demand and supply in Israel. (As a water-deficit region, the Gaza Strip was less important in this respect.) First, it increased Israel's fresh water supplies by almost 50 percent. Second, it gave the country almost total control over the headwaters of the Jordan River and its tributaries, apart from the Yarmuk, as well as control over the major recharge region for the Mountain Aquifer. Third, while the

Banias River, flowing off the Golan Heights, is a relatively minor source for the Jordan River, control of the Heights makes Israel the upper riparian on the river, which has important political and legal implications, and which was likely part of the rationale for its annexation by Israel. In recent months, the new Labour Government in Israel has offered to return part of the Golan Heights to Syria. However, it is not clear to what extent the offer includes the sources of the Jordan River and hence to what extent it is strategic for water policy -- nor for that matter whether Syria is interested in any offer less than return of the entire territory.

Finally, Israel solidified its position on the Yarmuk River (which forms the boundary between Jordan and Syrian and then joins the Lower Jordan River within Israel at a point just below the outlet from Kinneret). Israel was always a downstream riparian on the Yarmuk, but now, as a result of the war, it controls half of the river compared with 10 percent previously. This change allowed Israel to increase its use of Yarmuk water, and it now appears to be taking about 100 Mcm per year, most or all of which Jordan would like to regain to supplement its own very limited sources. More important, it made any upstream development of the Yarmuk dependent on Israeli consent. While secret negotiations between Israel and Jordan after the war permitted the latter to repair the East Ghor Canal on the Jordanian side of the river (Hosh and Isaac, 1992), better use could be made of the Yarmuk if a dam were built to store high winter flows -- but this requires agreement with both Syria and Israel, something that is unlikely in the absence of at least a limited peace agreement, and maybe not even then. (Syria has built 25 small dams to capture water draining southward the Yarmuk and would not want the value of these structures compromised.) More recently, according to Naff (1990), Israel refused to allow Jordan to dredge the entrance to the East Ghor Canal, which has been silting since it was re-opened two decades ago. By restricting the water flow out of the Yarmuk, the flow into the Jordan River is increased, which benefits Israel.

Control of the West Bank and the Golan Heights thus gave Israel access to additional water supplies and better control over existing supplies. As indicated above, Israel had for many years been tapping aquifers that rise on the West Bank from within the Green Line. Since the war, the country has become acutely dependent on the aquifers in this region, particularly for drinking water. Almost immediately after the war, Israeli water policies and institutions were extended to the West Bank. The effect of the extension is -- to use a provocative but nonetheless appropriate term -- de facto annexation of West Bank water resources.

In addition to direct use of water from the Mountain Aquifers from wells within Israel, West Bank (and Gaza) water is used to supply new Jewish settlements outside the boundaries of pre-1967 Israel. Taken together, about 70 percent of the groundwater on which Israel is dependent, and more than 33 percent of its sustainable annual water supply, originate in the Occupied Palestinian Territories, mainly in its aquifers. Such figures make it easier to understand (though not accept) the declarations of former Agriculture Minister Rafael Eitan (perhaps the most outspoken politician on the issue) that relinquishing control over water supplies in the Occupied Palestinian Territories would "threaten the Jewish state."

Zarour and Isaac (1991, 1992), together with other analysts, provide figures (see table 7) that allow one to make rough comparisons of daily water use per capita within Israel proper and by various aggregations in the Occupied Palestinian Territories (100 litres per capita-day is generally taken as the minimum for adequate health and sanitation).

**TABLE 7. SELECTED DATA ON WATER USE IN ISRAEL AND THE OCCUPIED PALESTINIAN TERRITORIES**

| Location | Litres of Water for Domestic Use, per capita, per day | Percentage of Cultivated Land that is Irrigated |
|---|---|---|
| Israel (within the green line) | 125 | 47 |
| West Bank | | 5 |
| Villages | 40 | |
| Towns | 100 | |
| Gaza Strip | 85 | 64 |
| Israeli Settlements | 250 | 69 |

In their view, Palestinians in the Occupied Palestinian Territories are entitled to at least one-quarter of the water resources of the region. They are now getting between one-twelfth and one-sixth.

## A Potential Surplus on the West Bank

The salient fact about water on the West Bank is that only about 15 percent (125 Mcm) of the total surface and underground supply goes to the people who have historically lived there. Of water from the Territories themselves, Israel pumps some 300 to 350 Mcm per year, with another 40 - 50 Mcm or so being extracted on the West Bank and going directly to Israeli settlements. Arab communities and farmers get about 54 Mcm per year, or about one-third of their total use from wells. The remaining two-thirds comes from river water, springs, and cisterns that collect run-off (Heller and Nusseibah, 1991; Zarour and Isaac, 1991). In short, only a small portion of aquifer water goes to Palestinians living on the West Bank, with the result that consumption in the more than 100 Jewish settlements is nearly half that of the entire Palestinian population. (These figures appear to be an accurate assessment of current water use on the West Bank. Lowi's (1991) claim that water use in the Israeli settlements is approaching that of the entire Palestinian population probably refers to well water alone.)

All water developments in the West Bank are carefully controlled by the Israeli Military Authority, working in collaboration with the Water Commission, which, as was noted above, reports to the Minister of Agriculture. Policies applied to Arab communities and farms on the West Bank are highly discriminatory (Lowi, 1992). For example:

-No Palestinian Arab individual or village has received permission to drill a new well for agricultural purposes since integration, nor even to repair one that happens to be close to an Israeli well. Some permits are granted to obtain water for domestic use.

-Palestinians are only allowed to drill shallow wells, 70 metres or so. In contrast, Mekorot prefers to drill to depths of 300 to 400 metres in order to get higher flow rates and better quality water. Mekorot wells each yield about 750 thousand cubic metres per year, while the Palestinian wells yield only 13 thousand (Heller and Nusseibah, 1991). In some cases, the deeper wells drain water from the shallower ones.

-Water allocations recognize only existing uses of water, which, so far as Arab agriculture is concerned, are those of 1968, and allocations are frozen at the 1968 level with only a small margin for growth.

-West Bank Arabs are not allowed to use water in farming after 4:00 p.m., despite the fact that evening is the traditional (and sensible) time to irrigate in arid regions.

-Reforestation is prohibited in the recharge areas of the aquifer, except on private plots, in order to promote maximum runoff and thus recharging of the aquifer.

These regulations are particularly severe because of the dependence of the West Bank on agriculture, and of agriculture on water. More than 85 percent of water used in the region is for irrigation (Zarour and Isaac, 1991). To compound the discrimination, Jewish settlements receive heavy subsidies for water in order to promote extension of agriculture. Naff (1990) calculates that the typical Israeli settler farms 50 hectares and irrigates for 250 days a year. He pays $0.10 per cubic metre for water that costs $0.34, with the total subsidy cumulating to $29,500 (1988 US dollars) per year. In contrast, West Bank Palestinians receive no subsidy at all. Roughly, Palestinian farmers pay for irrigation water what settlers pay for drinking water. Water supplied by local Arab authorities may be still more expensive, as high as $1.20 per cubic metre (Zarour and Isaac, 1992). Given that per capita income on the West Bank is only about one-fifth of that in Israel (and in the Gaza Strip even lower), the need for economic growth is self evident.

These (and other) discriminatory practices are enforced through the application of Israeli law to the West Bank. According to Zarour and Isaac (1991), "Although the new legislation conforms to the Israeli water law, it is not consistent with the rights of an occupying power under international law." Clearly, the dispute is in effect over sovereignty, not just over the division of water supplies.

Disturbing as this system is, it is important not to exaggerate. The issue is one of economic development, not of thirst. Water Commissioner Meir Ben Meir stated the issue starkly: "If the demand is for drinking, we must say 'yes'; we do say 'yes'. But we are not going to stop irrigating our orchards so they can plant new ones." This position appears to be consistent with international law. Baskin (1992, p. 6) notes that, "International law on belligerent occupation . . . only demands that the domestic water needs (home use) be accounted for. Industrial and agricultural development are beyond the definitions of the accepted international law." This does not mean that water supply has kept growth with population; since 1967, water allocations for domestic use have been increased by about 20 percent while population in the West Bank has grown by 84 percent (Baskin, 1992). However, it does mean that the principal concern is not that Palestinians will have insufficient water for household use; rather it is that they will have insufficient water to establish a viable economy.

The need for West Bank water in Israel and, therefore, its dependency on this resource is hotly contested. Former Water Commissioner Tsemach Yisahi agrees with Rafael Eitan and claims that Israel must hold onto the West Bank "to make sure that Tel Aviv's taps don't run dry." On the other hand, Gideon Fishelson of the Hammer Institute (University of Tel Aviv) argues that with more rational policies in Israel, there would be no need for West Bank water. Similarly, Arie Issar (Professor of Water Resources at the Blaustein Institute) says there is more to be gained in sharing than hoarding water resources (cited in Pearce, 1991b). Tahal seems to be coming to the same position. According to the Israeli newspaper Ha-Aretz (10 March, 1992), Tahal prepared a report that indicates how Israel could withdraw from the Occupied Palestinian Territories without jeopardizing its security of water supply. Unfortunately, military censors classified the document as secret at the request of the Minister of Agriculture.

Some analysts find that there could be a surplus of water on the West Bank. Zarour and Isaac (1991) indicate that the "water potential" for conventional sources of water is 850 Mcm per year, of which 620 Mcm is "easily available," which presumably means at moderate capital costs. This conforms closely to the figure from Heller and Nusseibah (1991) who state that aquifers wholly or partly located under the West Bank have a renewable flow of 615 Mcm per year. As indicated above, Israeli wells within the Green Line take about half of this; Israeli wells to supply settlements account for another 40 Mcm; and Palestinian wells for another 50 Mcm. Thus, both Zarour and Isaac (1991) and Heller and Nusseibah (1991) conclude the West Bank has a water surplus of about 200 Mcm per year, even excluding the water that is drawn from the nearly 300 springs in the area and by cisterns and tanks that hold rainwater and runoff. The implication is that there is considerable room for expansion of irrigated agriculture on the West Bank while still providing for industrial and population growth.

Not everyone agrees with the foregoing analysis. Starr and Stoll (1988) state that water in the Occupied Palestinian Territories is currently being exploited to its limit. And Naff (1990) states that the water of the Occupied Palestinian Territories is being over-exploited at a rate of 150 Mcm per year. (Both statements presumably include the Gaza Strip, but elsewhere in the same document Naff says the deficit in Gaza is 70 Mcm, so that in the West Bank must be 80 Mcm.) These conclusions may have been based on earlier data before hydrological studies indicated the full extent of West Bank water resources. However, Shuval (1992), who is fully aware of these data, concludes that the entire region is already, or soon will be, short of water, and that the only solution is to bring in additional sources of water from outside the region in a "Regional Water-for-Peace Plan." (The kinds of options recommended by Shuval will be discussed in Chapter VII.) Most Israelis attending the First Israeli-Palestinian International Academic Conference on Water held in Zurich in December of 1992 seemed to agree with Shuval. Palestinians were more cautious and argued that, were the distribution of water resources equitable, and were they able to manage these resources themselves, the West Bank could get along without additional supplies of water.

For the next few years, the volume of water resources potentially available to the West Bank is probably less important than the capital requirements for needed expansion of water supply and water delivery systems. High capital costs are the reason why such systems were avoided in the past, when water shortages were perennial. Even today water shortages persist in some parts of the West Bank. Farmers and communities with inadequate capital have to rely mainly on springs and shallow wells (supplemented by river water and storage of run-off in cisterns). Lack of access to capital -- or, more accurately, lack of access to capital at reasonable interest rates -- is also the reason that Palestinian farmers have used and continue to use inefficient irrigation methods.

## A Deficit in the Gaza Strip

The water balance in the Gaza Strip is much worse than that on the West Bank. The region is in deficit with the current population, and its economic development is well short of what would be necessary for adequate standards of living, and even shorter of that necessary for improving quality of life. According to a Dutch government report, Mekorot is supplying water to much of the area, including the towns, larger villages and certain refugee camps, through the National Water Carrier (Bruins et al, 1991). However, it is not clear whether Israel is actually supplying water to the Gaza Strip or is simply putting Gaza water into the Carrier. The situation is complicated because Israeli wells to the east of the Gaza Strip have apparently withdrawn water that would otherwise have flowed westward through the aquifer underlying the region. On the other hand, some Israeli hydrologists argue that overpumping of the aquifer predates the occupation and that new regulations have prevented an even worse situation.

What is clear is that the situation in the Gaza Strip is desperate from both quantity and quality perspectives. In the small but heavily populated territory, a good proportion of residents are already drinking contaminated and/or saline water (Zarour and Isaac, 1991; Shawwa, 1992). The shallow aquifers that underlie the Strip, one sweet and one saline, are both being overpumped, mainly for agricultural purposes; some 98 percent of all boreholes provide irrigation water. Israeli officials do not permit the drilling of more wells for irrigation (new wells are permitted for drinking water), but water levels continue to fall by 15 to 20 centimetres per year.

Conditions in the Gaza Strip appear are an example of what happens when all four types of water stress identified by Falkenmark et al (1989) overlap. Any reasonable resolution to the problem must include transfers of water from Israel. In these circumstances, it is hardly surprising that Israeli water policy for Gaza is different from its policy for the West Bank. Israeli policies and institutions were not extended to the Gaza Strip, as they were on the West Bank. Rather, old Jordanian Law No. 40 on soil and water is administered by the military authorities (Bruins et al, 1991). However, just as on the West Bank, Palestinians and Israelis tend to have sharply different prescriptions for dealing with the problem. Many Israeli analysts argue that the situation is so severe that immediate construction of new pipelines or desalination plants is appropriate. Palestinians are sceptical of this megaproject approach in part for fear that they will get stuck with expensive sources of supply and in part because it diverts attention from the inequity of distribution of existing supplies. Almost needless to say, here too the difference in approach also incorporates differing views about sovereignty over land and water resources.

## Pretensions to the Litani River

Although not connected to the Occupied Palestinian Territories, Israel's incursion into Lebanon and the establishment of the "Security Zone" in the early 1980s allows it access to the lower reaches of the Litani River (which flows within 10 km of the Israeli border). These actions, coupled with past unsuccessful attempts by Israel to reach an agreement with Lebanon to share Litani water, have led to great Arab concern that Israel will unilaterally divert the Litani into the Jordan River. Certainly the value of the Litani was recognized by Zionist planners (Lowi, 1992), and the traditional (and current) Israeli position is that the Litani is actually part of the Jordan River watershed. Also, more rain falls over the Litani than any other river in the region, and its flow is approximately 700 Mcm annually. Flow of the Litani at the lower end, however, is only 100 Mcm (Kolars, 1992). The fact that Litani water is very high in quality with a salt content of below 250 ppm only enhances its value -- and the perceived threat.

It seems unlikely, however, that Israel would attempt a diversion of the Litani without an explicit agreement with Lebanon. The Litani River lies entirely within the boundaries of what is internationally recognized as the borders of Lebanon (Figure 2). The government of Lebanon originally placed great priority on development of the river for the generation of electricity, and the construction of irrigation systems has largely been delayed because hydroelectric facilities were more profitable (Naff and Matson, 1984). If the political situation in Lebanon stabilizes, agricultural, industrial and population demands could place more pressure on water resources. Given current conditions, however, the continued high quality of the Litani will probably be maintained and demand will not reach unmanageable levels for some time (Naff and Matson, 1984). Still, Lebanon remains dependent on the Litani as a source of water, and if the state is to prosper it must continue to develop and harness the resources of the river.

Despite unsubstantiated claims to the contrary, the best evidence indicates that there have been no Israeli withdrawals of water from the Litani River to date, nor even construction of infrastructure to facilitate such withdrawal (Wolf, 1992). Occasional articles in the Arab press, and some in the United States claiming such withdrawals (e.g., Naff, 1990) appear to be in error. This does not mean that some Israelis do not covet the river. It is the only source that would allow Israel to maintain its present consumption rates and avoid the difficult choice to reallocate water away from agriculture. Lebanese analysts now believe that the Litani can (and should) be fully utilized for economic development within Lebanon itself (Kubursi and Amery, 1992), and it is unlikely to play a role in the future Israeli water balance.

## Water as a Security Issue

> ...environmental degradation imperils nations' most fundamental aspect of security by undermining the natural support systems on which all of human activity depends.
>
> Because environmental degradation and pollution respect no human-drawn borders, they jeopardize not only the security of the country in which they occur, but also that of others, near and far.
>
> (Renner, 1989)

It is undeniable that there have been conflicts over water resources involving Israel and its neighbours over the past 45 years. While the reasons for violent confrontations defy simple explanation, it is increasingly acknowledged that, in the complex web of causality of war, environmental factors are often a key feature (Myers, 1986; Russett, 1982; Westing, 1986; Homer-Dixon, 1991). Ullman (1983) notes that the root of most violent conflicts in history was competition for territory and resources, and that the conflict over resources is likely to become more intense as the demand for essential commodities increases and supply appears more precarious. All nations require a continuous supply of food, water, fuel and raw materials, and the need for assured access to these resources provides a powerful driving force toward conflict. In addition, so long as the concept of national sovereignty remains sacrosanct, a state's resort to arms to retain control of its own natural resources or to protect its access to extraterritorial sources will remain a frequent means of conflict resolution (Westing, 1988).

The concept of environmental or ecological security is now emerging and, while an established definition does not yet exist, the idea is evolving quite rapidly (Schrijver, 1989; Homer-Dixon, 1991). There is also a growing recognition that comprehensive human security has two components, one political and the other environmental. Neither of these components is attainable or sustainable unless the other is satisfied, and the fact that national security relates to such factors as watersheds, croplands, forests, genetic resources and climate is less often overlooked now than it was in the past (Westing, 1989).

Israel's application of restrictions on Palestinian development and use of water not only improves its access to West Bank water, but also extends its control in the Occupied Palestinian Territories. This increases resentment and adds to the potential for conflict in the area. Arabs in the West Bank have protested for years to Israeli authorities that their agriculture and economy are being retarded or even ruined by unfair water policies, and that the water network supplying the Jewish settlements has drastically depleted the villages' water resources. However, the Palestinians have been frustrated in their efforts to change their circumstances and, given no power, they can only watch their wells dry up and turn saline while water is diverted to Israel. While some of the Palestinian charges are disputed (see Appendix I), the issue is a highly emotional one, and a number of authors have used the metaphor that the water situation in the Occupied Palesintian Territories is a "time bomb waiting to explode."

## The Current Negotiations

Officially, little has happened to resolve water issues since 1967. Unofficially, Israel and Jordan have been meeting at "picnic table summits" to discuss joint water concerns; for example, Israel has apparently allowed some dredging of the East Ghor Canal. However, it is unclear what of lasting consequence has been accomplished at these meetings. The Israelis feel they are a major step towards inter-basin cooperation, while the Jordanians note that they are of little use and have had no effect on Israeli behaviour relative to water. Clearly, Israel and her neighbours have quite different approaches to negotiations over water.

These differing views are evident in the current multilateral talks over water that are carried on in parallel with the higher profile bilateral Middle East peace talks. In these discussions, Israel focuses on "low politics;" that is, they emphasize that, whatever other conditions obtain, there is a great deal to be gained pragmatically by joint management of shared water resources in order to realize limited but significant gains in efficiency and welfare (Rothman and Lowi, 1992; Lowi, forthcoming in 1993). The Palestinians (and the Jordanians) in contrast focus on "high politics;" that is, they emphasize the need for overall peace agreements and strategic management of people and economic development before resolution of tactical water issues.

Some analysts see ulterior motives in the "functionalist" Israeli approach. Zarour and Isaac (1991) suggest that Israel uses the water issue so as to be able to keep talking without really resolving anything. Rothman and Lowi (1992) tend to agree that functionalist low politics are inadequate in the case of intense, protracted and culture-laden conflicts. Elsewhere, Lowi (forthcoming, 1993) has argued that what surfaces as a dispute among riparians takes on the attributes of the greater conflict, and that therefore the riparian dispute cannot be resolved or even much mitigated in the absence of some sort of ideological consensus, which in this case would have to involve the establishment of an independent Palestinian state.

However, water is so essential to life that it can promote cooperation as easily as conflict. Even in the absence of consensus on high political issues, there may be benefits to be obtained from cooperation on water management and supply. Thus, Rothman and Lowi go on to suggest that, with the parallel bilateral and multilateral tracks of the current peace process, we may at last be witnessing the "iterative process by which progress beginning at the political process -- that is, the Arab-Israeli peace process -- requires concrete progress at the practical level -- for example, sharing water resources -- for both consolidation and fruition" (1992, p. 69). Shuval, a hydrologist rather than a political scientist, comes to the same conclusion from a different perspective: "Just because the situation is so desperate, the partners to the dispute may finally realize that only by joining hands in a cooperative effort can they survive" (1992, p. 143).

Security of water resources is a major objective of all countries, but hydrology, economics and politics combine to make it particularly important to those in the Middle East. The options presented in the next chapter must be assessed both in terms of long-term environmental and demographic change occurring in the region, and in terms of how they affect security of water supply to Israelis and to Palestinians.

# VII. REGIONAL OPTIONS FOR THE FUTURE

> One of the paradoxical qualities of hydropolitical problems is that, despite their complexities and stubbornness, they exhibit a tendency in certain circumstances to encourage negotiations where other problems would degenerate into conflict. There is an underlying superordinate interest common to all riparians -- water is essential to life -- that sometimes can be made to override discords and produce agreements on water issues.
>
> (Naff, 1990, p. 158.)

There are numerous strategies available to Israel to deal with its water crisis. Some are complementary; others mutually exclusive; and all are limited by economic, social or political constraints. Previous chapters have focused mainly on options that are available for Israel to undertake on its own. This chapter focuses on regional options. The first section below offers a brief review of relevant international law and of suggestive Canadian experience with inter-jurisdictional agreements for water. It then goes on to review a number of options, including agreements for sharing water; regional sales of water; long-distance importation of water; and militarization (with or without annexation) to acquire additional supplies. (The last in the list, militarization, should not be viewed as an "option," but as a possible result if all other approaches are unsuccessful.) The chapter concludes with discussion of an alternative approach to water planning.

## International Law of Shared Water Resources

In 1959, Israel adopted its first comprehensive water legislation, which declared that water resources were public property, subject to control by the state, and to be used by residents of the state for the purpose of development of the country (Teclaff, 1985). This legislation included ***all*** water resources, both surface and subsurface, as well as drainage and sewage water. While no individual or group could own water (or have exclusive right to its use), the legislation guaranteed that everyone had the right to receive water. Domestic use, agriculture, industry, handicraft and commerce, and public services were explicitly recognized as legitimate uses. All licensing of water use was made by the Water Commissioner, and all water management was to be administered by the Ministry of Agriculture and the Water Commissioner.

This legislation was adopted in the context of ongoing discussions on the international law dealing with transboundary waters. International law in this area, however, has been largely ineffective, since any legal obligation has been based only on general principles, and, as Caponera (1985) notes, the real difficulties in water resource management concern the political willingness of states to enter into formal cooperative arrangements regarding water resources.

### *Surface Water*

Historically, conflict over the use of water resources has stemmed from the adoption of one of two principles of sovereignty over water by riparian states. In general, upstream states have preferred the principle of absolute territorial sovereignty, whereby a state has the exclusive right to use and dispose of international waters which flow through its territory. Alternatively, absolute territorial integrity, the preferred principle for downstream riparians, implies that downstream users are to be provided with unaltered water volume and quality. However, the rule of law dealing with the non-navigable use of water resources has most recently been based on general principles and recommendations arising out of United Nations rulings or on past principles used by states within water basins or systems. Although no general rule of international law exists, two principles are commonly accepted:

(1) Common water resources are to be shared equitably among the states entitled to use them, with related principles of:

(a) limited sovereignty;
(b) duty to cooperate in development; and
(c) protection of common resources.

(2) States are responsible for substantial transboundary injury originating in their respective territories. (Caponera, 1985; Teclaff, 1968, 1985).

Historically, international relations on the use and development of water resources were based on navigation. Significant consumption for multiple uses in the last half century has resulted in numerous conflicts over international river basins and has stimulated a need for laws which adequately cover transboundary water use. Gleick (1991) has noted in almost 50 countries the percentage of land which falls in international river basins is greater than 75 percent. In addition, 13 major rivers have five or more riparian states. This has resulted in major recent conflicts on the Danube, Indus, Ganges, Euphrates, Jordan, Plata, and Nile Rivers.

In 1966, the International Law Association adopted the "Helsinki Rules", which provided general guidelines for water resource use on the basis of watershed boundaries. More recent UN documents (e.g., UN, 1983) have adopted the use of a watercourse system to describe the water resources shared by many states not simply as a physical unit, but as a system that connects to other components and resources.

The key article of the Helsinki Rules of 1966 is Article IV, which states that, "Each basin State is entitled within its territory to a *reasonable and equitable* share in the beneficial uses of the waters of an international drainage basin." This principle was further described in an International Law Commission Report in 1983 (ILC, 1983):

> An international watercourse system and its waters shall be developed, used, and shared by system States in a *reasonable and equitable* manner on the basis of good faith and good neighbourly

> relations with a view to attaining optimum utilization thereof consistent with adequate protection and control of the watercourse system and its components.

Determining what is "reasonable and equitable," of course, is the relevant question. What is reasonable depends on the natural features of a given watercourse, while equity depends on the social, economic and political context. The Helsinki Rules of 1966 and the ILC Report of 1983 detail the list of factors that should be considered in determining what is "reasonable and equitable" (Table 8). While reasonableness and equity cannot be considered rules of law, as Caponera (1985) notes, they do amount to a rejection of the principle of absolute territorial sovereignty of a state over international water resources which may flow through its country. Additionally, these two sets of rules also amount to a rejection of the concept of absolute territorial integrity.

The implication of these rules is that states bordering an international watercourse have the duty to cooperate to ensure the long-term future of these water resources. This duty includes the protection of both the quantity of water as well as the quality of the water for other riparians. States must also account for any activities which adversely affect the interests or rights of other states. This duty was stated explicitly in a 1974 resolution of the UN General Assembly on the Charter of Economic Rights and Duties of States. It states:

> In the exploitation of natural resources shared by two or more countries, each State must cooperate on the basis of a system of information and prior consultation in order to achieve optimum use of such resources without causing damage to the legitimate interest of others...all States have the responsibility to ensure that activities within their jurisdiction or control do not cause damage to the environment of other States or of areas beyond the limits of national jurisdiction.

**TABLE 8. THE PRINCIPLES OF REASONABLENESS AND EQUITY, ACCORDING TO THE HELSINKI RULES OF 1966 AND THE INTERNATIONAL LAW COMMISSION (1983).** (ADAPTED FROM CAPONERA, 1985)

According to the Helsinki Rules (ILA, 1966):

(1) What is reasonable and equitable share...is to be determined in the light of all the relevant factors in each particular case.

(2) Relevant factors which are to be considered include, but are not limited to:

(a) the geography of the basin, including in particular the extent of the drainage area in the territory of each basin State;
(b) the hydrology of the basin, including in particular the contribution of water by each basin State;
(c) the climate affecting the basin;
(d) the past utilization of the waters of the basin, including in particular existing utilization;
(e) the economic and social needs of each basin State;
(f) the population dependent on the waters of the basin in each basin State;
(g) the comparative costs of alternative means of satisfying the social and economic needs of each basin State;
(h) the availability of other resources;
(i) the avoidance of unnecessary waste in the use of waters;
(j) the practicability of compensation as a means of adjusting conflicts among users; and
(k) the degree to which the needs of a basin State may be satisfied, without causing substantial injury to a co-basin State.

*continued on page 88*

**TABLE 8.** CONTINUED

According to the ILC Report of 1983 (ILC, 1983):

1. In determining whether the use by a system State of a watercourse system or its waters is exercised in a reasonable and equitable manner in accordance with article 7, all relevant factors shall be taken into account whether they are of a general nature or specific for the watercourse system concerned. Among such factors are:

(a) the geographic, hydrographic, hydrological and climatic factors together with other relevant circumstances pertaining to the watercourse system concerned;
(b) the special needs of the system State concerned for the use or uses in question in comparison with the needs of other system States including the stage of economic development of all system States concerned;
(c) the contribution by the system State concerned of waters to the system in comparison with that of other system States;
(d) development and conservation by the system States concerned with the watercourse system and its waters;
(e) the other uses of a watercourse system and its waters by the State concerned in comparison with the uses by other system States, including the efficiency of such uses;
(f) cooperation with other system States in projects or programmes to attain optimum utilization, protection and control of the watercourse system and its waters;
(g) the pollution by the system State in question of the water course system in general and as a consequence of the particular use, if any;
(h) other interference with or adverse effects, if any, of such use for the uses or interests of other States including but not restricted to, the adverse effects upon existing uses by such States of the watercourse system or its waters and the impact upon protection and control measures of other system States; and
(i) availability to the State concerned and to other system States of alternative water resources.

*Underground Water*

The distribution of fresh water on the Earth readily justifies the emphasis on groundwater concerns internationally; 77.2% of freshwater is found in ice, 22.4% in groundwater, 0.36% in surface water and 0.04% in gas in the atmosphere. International law for groundwater, however, is both more and less developed than that for surface water. It is less developed in the sense that it came to be an issue much later in the history of international law for shared natural resources, but it is more developed in the sense that, partly because of that lag, there has been systematic thinking about a technically and legally adequate regime for international groundwater resources. However, only since the Helsinki Rules of 1966 has groundwater been formally included within the scope of legal discussions about international drainage basins (Hayton and Utton, 1989).

In one way it is strange that the development of international law for groundwater has lagged so badly. More than 60 times as much fresh water occurs underground as occurs in lakes and rivers (Pearse, et al, 1985), and many industrial countries depend heavily upon groundwater -- three-fourths of all the water used in Denmark and the Netherlands, and nine-tenths of that in Belgium, is groundwater (Hayton and Utton, 1989). (The situation in Canada is quite different; only about 4 percent of our water comes from underground sources.)

No less than surface sources is groundwater inclined to stay within a political boundary. The Disi Aquifer underlies Jordan and Saudi Arabia, and contains an enormous quantity of nonrenewable fossil water. It is heavily pumped (1600 Mcm per year, with lion's share going to Saudi Arabia); the water is currently used for irrigation as the aquifer does not occur near population centres. However, despite huge capital costs and high pumping costs, the water may eventually be piped to Amman, some 300 km from and 1000 m above the wells. The Northeast African Aquifer underlies parts of Chad, Sudan, Libya and Egypt, and is being affected by the Libyan project to build a 1600-kilometre canal from an oasis in the southern part of the country to the coast. In short, only the specific political problems make the situation between Israel and the West Bank unique.

The general principles of management for political entities sharing groundwater resources are similar to those for surface water. As expressed by Barberis (1991, p. 167), they are:

> ". . . the obligation not to cause appreciable harm to shared resources, the duty of equitable and reasonable use, the obligation of prior notification, and the duty to negotiate."

Barberis also points out that, even in the absence of accepted law for groundwater, there is a more than 100-year history of the successful application of these principles. However, optimum management can become highly complex when it is not just a question of trans-boundary groundwater but also of interactions between groundwater and surface water or of political boundaries between the location of the aquifer outflow and its recharge area, exactly the case of the Mountain Aquifer in Israel and the West Bank.

The most significant new development in the international law of aquifers is a draft treaty developed over eight years by an international group of specialists (Hayton and Utton, 1989. The Bellagio Draft Treaty focuses on mutual agreement among those entities that share the aquifer and is remarkably comprehensive. Besides the obvious areas of withdrawal and recharge, it includes articles dealing with contamination, depletion, and transboundary transfers. Special provisions are made for drought conditions, including equitable sharing of any hardships; for public participation; and for a series of dispute-resolution techniques up to and including formal arbitration or submission to the International Court of Justice.

Might such a treaty work for Israelis and Palestinians? Certainly, they each have more to gain (Palestinians in the near term; Israelis in the long) by coming to agreement than by taking unilateral action. Moreover, the treaty is designed expressly to minimize interference with national actions. It is worth quoting at length from the Hayton-Utton description of the approach taken in the Bellagio Draft Treaty:

> In order to minimize the intrusion into the sovereign sensitivities of independent countries, three concepts are used:
>
> 1. rather than comprehensive administration along the entire border, control is to be asserted only in zones considered to be critical because withdrawals are exceeding recharge or contamination is threatening groundwater quality;
>
> 2. actual enforcement would be left to the internal administrative agencies of each country with oversight and facilitating responsibility lodged in an international agency; and
>
> 3. the 'black letter' provisions delegate only a limited amount of substantive discretion to the joint agency, but, above all, they instruct the Commission to take the initiative, subject to Governments' approval, in preparing for and confronting the full range of problems involving the Parties' transboundary groundwaters. (Hayton-Utton, 1989, pp. 664-65)

This approach seems reasonably likely to satisfy those who will sooner or later be faced with negotiating an agreement on sharing the aquifers that underlie Israel and the Occupied Palestinian Territories.

### *Relevant International and Canadian Experiences*

There have been numerous experiences internationally with the application of water law and the development of insitutional frameworks and formal cooperative arrangements regarding transboundary water resources. Four of these are discussed below, primarily to provide context of the range of agreements that have been implemented. Two of these involve Canada, and one is solely within the country (the Prarie Provinces Water Board). Since the Canadian provinces have ownership over resources within their boundaries, the interjurisdictional water issue in Canada is much like dealing with an international river basin. These examples represent the types of institutional arrangements which may be appropriate in the Middle East.

***International Joint Commission (IJC):*** The International Joint Commission is a permanent, impartial tribunal consisting of six members, three from the U.S. and three from Canada. It was established as an institutional mechanism under the 1909 Boundary Waters Treaty between the two countries which set out to bring about rational water management of the transboundary waters. The IJC attends to three basic functions. First, it sits as a regulatory body that manages the levels and flows of boundary and transboundary waters. Second, it is a commission of inquiry, to monitor, investigate and report on problems along the common frontier between the U.S. and Canada. And, third, it serves as a court of arbitration, providing principles for the equitable uses of boundary waters. The role of the IJC is similar to the UN Security Council and GATT, in that it arbitrates disputes between the two countries and has the power to prescribe conditions and provide protection from indemnity for injuries arising from the action of one of the two parties on the other. The Commission, however, has no policing powers and hence cannot actively enforce its decisions, and must draw on other institutional means for enforcement.

***The Prarie Provinces Water Board (PPWB):*** The Prarie Provinces Water Board is the administering agency for a cooperative surface water apportionment agreement among three provinces in Canada: Alberta, Saskatchewan and Manitoba. This agreement represents the only interjurisdictional apportionment agreement in Canada, and it serves as a useful model of the type of agreement that could be signed in the Jordan River Basin. The agreement specifies the "reasonable and equitable" apportionment of river waters by alloting provinces 50 percent of the natural flow arising in or flowing through an upstream province, thereby balancing the concepts of territorial sovereignty and territorial integrity. All water diversions and consumptive uses come under the agreement. The weaknesses of the agreement are twofold: it allows provinces unilaterally to pass legislation that would exempt that province; and actions are only taken with the agreement of all parties. Its strength, however, is that it establishes a regional authority with the ability to resolve interjurisdictional disputes.

***The Mekong Committee:*** The Mekong Committee was established in 1957 under the auspices of the United Nations Economic Committee for the Far East and Asia, as an independent body, to formulate a comprehensive plan for the development of the Lower Mekong. The Committee is comprised of the four riparian countries (Cambodia, Laos, Vietnam and Thailand) along with the assistance of 21 other nations and 12 international agencies. The primary goal of the Committee is to promote the "comprehensive development of water resources and related resources of the lower Mekong basin." Despite the difficult political situation in the region over the last two decades, the Committee has acted to develop an integrated planning approach to the Mekong, and recently has concentrated on hydroelectric development. The effectiveness of the Committee has been largely undermined by political problems and distrust, and it has been criticized for not responding to democratic and environmental criticism. Nevertheless, it appears the Committee will play an important role in river basin planning over the next few decades.

***The Joint Rivers Commission (JRC):*** After Bangladesh's independence in 1972, a 25 year "friendship treaty" was signed with India. One of the articles in the treaty incorporated water issues, such as river basin development, flood control and hydro-electric power generation. Soon after, a Joint Rivers Commission was established to promote development of the Ganges/Brahmaputra basin. The mandate of the JRC was limited to project development, and excluded the question of water sharing or policy development. Although it represented the first formal forum in which bilateral technical discussions over water were held, the political nature of the Commission, disagreement over shared information, and the dispute over water sharing have limited the utility of the JRC in resolving transboundary water conflicts in the region.

## Regional Options Worth Considering

### *Agreements to Share Water*

In 1948, the first formal Israeli plan to develop the Jordan Valley's water resources, known as the Hays Plan, was developed, and entitled, "TVA on the Jordan, Proposals for Irrigation and Hydro-Electric Development in Palestine." Wishart (1990) notes that this was an elaboration of earlier proposals calling for diversion of the Jordan River to irrigate the Mediterranean coast and the Negev. Part of this early plan included the diversion of the Yarmuk River, shared by Syria and Jordan with Israel (then a minor downstream riparian; see Figure 2), to Lake Kinneret, which could then serve as a natural reservoir for both Israel and Jordan. At the same time there were discussions about building a canal between the Mediterranean Sea and the Jordan Valley and using the natural drop in elevation to generate hydroelectric power.

The first formal plan for water management from Jordan during this period was the MacDonald Report in 1951 (Wishart, 1990). The MacDonald Report outlined the conflicts between Jordan and Israel, particularly with regard to inter-basin transfers of water, and proposed that all developed water remain in the Jordan Valley. The proposal also included the Hays component of diverting the Yarmuk into Lake Kinneret. Shortly thereafter, concerned over sharing a reservoir with Israel, Jordan and Syria proposed a high dam on the Yarmuk River that would provide water storage and hydroelectric capacity.

In late 1953, the U.S. took a more active role in water planning in the region, and President Eisenhower appointed Eric Johnston as a special ambassador to negotiate a water agreement among the riparian states. A secondary issue that was linked to the water negotiations was permanent settlement of 800,000 Palestinian refugees. With the exception of water diversions by Israel from the Jordan River to the coast, the Johnston Plan was similar to the above plans and contained three major planning components: storage, distribution, and allocation. Water storage included components from both earlier proposals for diverting Yarmuk River water and consisted of the construction of two primary facilities, a dam near Maqarin with a capacity of 300 Mcm for irrigation and power generation, and storage of Yarmuk River flood flows in Lake

**TABLE 9. ALLOCATIONS OF THE JORDAN RIVER UNDER THE JOHNSTON PLAN (AND COUNTER-PROPOSALS BY THE ARABS AND ISRAELIS)**

| | **Johnston 1953** | | Arab Tech. 1954 | | **Cotton 1954** | |
|---|---|---|---|---|---|---|
| | **Water** | **Area** | Water | Area | **Water** | **Area** |
| Jordan / Palestine | **774** | **490** | 861 | 490 | **575** | **430** |
| Syria | **45** | **30** | 132 | 119 | **30** | **30** |
| Lebanon | **-** | **-** | 35 | 35 | **450.7** | **350** |
| Arab States | **819** | **520** | 1 028 | 644 | **1 055.7** | **810** |
| Israel | **394** | **420** | 200 | 234 | **1 290** | **1 790** |
| **Total** | **1 213** | **940** | **1 228** | **878** | **2 345.7** | **2 600** |

N.B.: water volume measured in million cubic metres.
area measured in thousands of dunams.

*Source: Issac and Hosh, 1992.*

Kinneret (also approximately 300 Mcm per year). The distribution system focused primarily on providing water to Jordan's East Ghor Canal, which supplies most of the surface water to the country. Water allocations were based on the principle that Arab states receive enough water to meet their irrigation needs with the remaining water divided between Jordan (the Yarmuk) and Israel (the Jordan).

Agreement based on the Johnston Plan was reached for apportionment of Jordan River water (see Table 9), at least by the technical advisors. Discussions on the Johnston Plan concluded in 1955, after political bickering effectively derailed all negotiations. Wishart (1990) presents a detailed explanation of the negotiations and the eventual breakdown, and concludes that the Arab states had little to lose by not entering into the agreement; indeed many of the projects outlined in the Johnston Plan were subsequently undertaken unilaterally by the riparian states. As well, formal acceptance of the plan by all the riparians would have amounted to implicit recognition of the sovereignty of Israel, something the Arab states were unwilling to grant at the time. Nevertheless, all of the riparians unofficially accepted the Johnston Plan, with the exception of Syria, which did not reject it, but simply failed to accept it (Sabbagh, 1992). It is also worth noting that there was no explicit allocation in the Johnston Plan for the Palestinians; their water was included in the Jordanian share. It is doubtful whether either Israel or Syria would now accept the Johnston Plan, since both have installed and operate their own water infrastructure which gives them more than their share alloted to them by Johnston.

Since 1955, there has been little discussion over shared water agreements. Countries in the region have continued to develop their water resources, commonly at the expense of other countries. In addition, groundwater, which was not covered in the Johnston negotiations, has now become an important issue, particularly for Israel and the Occupied Palestinian Territories. Subsequent to dissolution of the Johnston Plan, Israel constructed the National Water Carrier, and Jordan further developed the East Ghor Canal off the Yarmuk River for irrigation. Plans for a major multi-purpose (irrigation, drinking water, hydropower) dam on the Yarmuk River were revived by Jordan and Syria in the early 1970s Israel's territorial gains from the 1967 War had provided it with a stronger riparian position on the Yarmuk, and, because impoundment of

Yarmuk flows would affect downstream availability of water, Israel now had to be consulted and agree to the proposal. Before agreement between Israel and Jordan could be reached, problems arose between Syria and Jordan, with the result in 1980 that the Maqarin Dam project was postponed (Taubenblatt, 1988).

More recently, Zarour and Isaac (1992) have proposed a "pragmatic, applicable and dispassionate formula" for allocation of water rights. Beginning from the principles of limited territorial sovereignty in water use, and of the drainage basin, including both surface and underground water, as the relevant unit of analysis (based on the Helsinki rules of 1966 and 1987), they develop an equation that grants rights on the basis of equal weighting of contributions to supply and the sum of human withdrawals and natural losses. In a different approach to setting allocations by formula, Moore (1992) offers four possible definitions of equity, all acceptable under the Helsinki rules: existing water utilization, recharge area, natural flow, and population. He then suggests that the "optimal allocation regime" (elsewhere termed the "least worst regime") can be determined mathematically by minimizing the summation of the 'error distances' from a notional line connecting points of 100 percent allocation to Palestinians and 100 percent allocation to Israelis.

Though intriguing, such formulae seem too rigid to satisfy the many concerns other than geography and economic power (some might say "greed"). Perhaps an attempt should be made to apply the different formulae on paper to a number of situations and consider whether the derived results are likely to be acceptable to the relevant parties. However, the range of approaches suggested does show that the definition of equity is anything but obvious, and that there do exist methods that would provide negotiators with at least indicative regimes for sharing available water.

Although these past efforts at reaching basin-wide agreements on the water issue illustrate the inherent difficulties in such an approach, it is also apparent that there is an immediate need for a cooperative mechanism to be established to work towards a shared agreement. The emphasis should be on bilateral and multilateral approaches that are addressed at the same time as the political conflicts are being discussed. The political conflict will not be resolved in the absence of an agreement on the water issue, and it is unlikely that the international water issues can be solved without some political agreement.

*Commercial Transactions for Sale of Water*

A number of authors have suggested that the evident surplus of water on the West Bank could, after independence is achieved, become not only a resource for internal development but also one that could be sold for hard currency. Heller and Nusseibah recognize this potential but are cautious in their suggestions:

> It is conceivable that the primary benefits that [the new Palestinian] state will derive from the river waters will be indirect, for example, through an agreement with Israel to make use of its National Water Carrier or to purchase at reduced rates certain water-intensive agricultural produce from Israel. (Heller and Nusseibah, 1991, p. 112)

Somewhat in contrast, Zarour and Isaac suggest full acceptance of water as a market commodity, with potentially significant benefits for a future Palestine:

> An international open water market in the Middle East would be a good promoter of international cooperation in the area. Countries with water surpluses would be willing to trade water with short fall countries, in an arrangement fairly valuing water like any other commodity. . . . One potential application of this would be that the anticipated Palestinian entity could trade water rights with rights to access and use Israeli costs. (Zarour and Isaac, 1992, p. 23)

Canadians may have some qualms about the final sentence, given the way some sectors in the United States have cast longing glances at water to the north, but the same perspective should give them grounds for recognizing why Palestinians at all levels feel that water is such a critical resource for their future. Just as with Canadians, the issue for Palestinians is less whether there will be enough water for drinking and sanitation than whether water will be available in large enough quantities and low enough costs at appropriate locations for sustainable economic development.

In an earlier article, Zarour and Isaac (1991) had suggested a variation on the proposal for an open market in water. They propose using the water surplus they find in the West Bank to supply the Gaza Strip, which has a water deficit. No mention is made of an financial aspects, but, however one does the sums, it would surely be cheaper and technically more efficient to work out a trade, under which the West Bank would supply Israel and Israel in turn would supply Gaza.

In summary, it seems that some form of controlled rather than fully open market for water could play a role both in balancing water supply and demand across borders and in supporting the economy of an underdeveloped Palestinian entity. Whether such a market could serve as a model for other states in the region or other areas of the world is too difficult to say at this time.

### *Importation of Water by Sea*

Importation of water is under active consideration in the Middle East. Apart from short-term and small-scale deliveries by tanker trucks, the two options most relevant to Israel involve transportation by pipeline from Turkey or Egypt, and by ship or barge from one of a number of countries but most likely Turkey. This section will include a review of the prospects for importing water by sea as a long-term option. The next section will review the prospects for international pipelines.

Had the long drought continued into 1992, Israel would likely have imported water from Turkey using converted oil tankers to meet its short-term needs for domestic and municipal water. Turkey is the one country in the region with an unqualified surplus of fresh water, and rivers such as the Manavgat (which flows at an average rate of 140 cubic metres per second[6]) appear to be large enough to supply, and deep enough offshore to provide anchorage for, ocean-going

[6]For purposes of conversion, 3.2 cubic metres per second is equivalent to just under 100 million cubic metres per year.

vessels. (Some analysts also suggest Lebanon as a source of water for export, but any surplus there will soon be absorbed by a growing population and economic development (Kubursi and Amery, 1992).) Loading facilities are not negligible in either scale or cost, but neither is there anything unique about the design -- mainly tunnels and piping that, assuming a Manavgat source, would link a dam 12 kilometres upstream on the river to an off-shore loading terminal.

Two main options have been considered: (1) converting oil tankers, perhaps supertankers, to carry water; and (2) loading the water into large bags that will be towed by tugs. The latter go by the name of "medusa bags" (not by reference to the character of Greek mythology but because they float easily as do the jellyfish of that name, allowing waves to pass through them).

There have been a number of estimates of the costs of operating a tanker delivery system, and the estimates range by a factor of about three: from $0.35 to $1.10 per cubic metre. Per cubic metre of water delivered, supertankers can operate for much less than can smaller tankers, but conversion costs and loading facilities (mainly because of their deep draft) are much higher. At the lowest end of the cost estimates, which most analysts question, the tanker option would be marginally of interest.

Potentially more important are medusa bags, which happen to be a Canadian technology (Cran, 1992). The bags, each of which carries about 1.5 Mcm, are made of thick nylon coated with vinyl and reinforced with nylon straps. According to a study by Tahal (1989), costs for a complete system (bags, tugs, loading and unloading facilities, and even a 5 percent royalty) with a capacity of 250 Mcm per year would be $0.17 to $0.23 per cubic metre, depending mainly upon interest rates and the capacity factor (ie, the proportion of time each bag is carrying water as opposed to waiting at the terminal or in maintenance). Initial capital was estimated at about $280 million for a six-bag/six-tug system. While some technical uncertainties remain -- uncertainties that, Tahal warns, could increase costs considerably -- its initial estimates of costs make medusa bags competitive with some conventional sources of supply and very much so with most alternative sources. Environmental impacts are not mentioned by Tahal but, apart from construction, should be small. Of all the alternatives, the medusa bags seem to be most deserving of funding for prototype design and construction.

Even assuming that importation of water in medusa bags is economically attractive for Israel or other coastal nations in the region, transportation of water by sea, regardless of the means of conveyance, faces serious political barriers. Turkey was apparently so embarrassed by a 1990 article in the Wall Street Journal discussing possible water sales to Israel that it broke off negotiations. Adverse Arab reactions could be reduced if the imports to Israel were balanced with a release by Israel of equal volumes of, for example, Jordan River water for use in the Occupied Palestinian Territories or in Jordan. In this way, the imports would become part of a regional solution.

Water tankers or barges are, of course, extremely vulnerable from a military point of view (as would be transportation by pipeline, as discussed below). Two options have been suggested to reduce the risks of hostile action. First, if the imports are explicitly coupled with releases of water to Arab states, as suggested just above, an agreement could be signed such that any shortfalls resulting from hostile action would be shared among all the parties. Second, instead of using the water to feed directly into distribution systems, it could be used to recharge the Coastal Aquifer. In effect, the imported water would be treated as "capital" for future consumption rather than as "income" for immediate consumption. To this extent, it would mimic the Gur pipeline proposal and also eliminate the fear that any city would go thirsty because a ship had been lost. Indeed, use of imported water for recharge should reduce costs because it would eliminate the need for storage facilities to allow for delayed deliveries because of bad weather and to accommodate seasonal differences in water demand.

### *Importation of Water by Pipeline*

Importation of water by pipeline as a long-term solution to Israel's water problems is also under consideration. Egypt and Turkey have both been mentioned as possible input sources for the pipeline. Despite some initial enthusiasm in Israel and Egypt for a pipeline to transfer Nile River water to Israel, Gaza and the West Bank (Kally, 1989), interest has cooled considerably. For one thing, Egypt sees less and less of a surplus in the Nile, and, for another, diversions of this scale would require agreement among all nine of the nations that lay claim to some portion of the Nile River.

Active interest in pipelines more recently has come from Turkey, which would like to play a major role in the future as water broker for the region. Perhaps 98 percent of the Euphrates River has its source in Turkey (Kolars, 1990). The river flows from central Turkey through Syria and then Iraq before emptying into the Persian Gulf, and it probably holds the greatest potential for supplying water to those parts of the region suffering from a water deficit. However, all depends upon Turkey's "water plan," which is based on its Southeast Anatolia Project (GAP), including a number of major dams, some already built and some under construction or still in the planning stage.

So far as Israel is concerned, the relevant part of the plan is a Turkish proposal to build two pipelines (generally referred to in the singular as the "Peace Pipeline") to take water from two rivers, the Seyhan and the Ceyhan that empty into the Mediterranean Sea, southward to the Arab states and maybe Israel (Figure 6). (Kolars (1990) indicates that these two rivers do not have enough water but that the Goksu River does and only requires that the pipeline be 80 kilometres longer.) The western line would extend 2800 kilometres and pump 3.5 Mcm of water per day (1300 Mcm per year) to Syria, Jordan, and western Saudi Arabia; this line could include an extension into Israel. The eastern line would cover 4000 kilometres en route to the Persian Gulf through Kuwait, eastern Saudi Arabia, Bahrain, Qatar, the United Arab Emirates and Oman. The two pipelines together would cost $21 billion. A more modest "mini-pipeline" has also been proposed (though not by Turkish officials) to supply water to Syria, Jordan and the West Bank. It would have a capacity of about 2 Mcm per day (730 Mcm per year) and cost perhaps $5 billion.

The success of any of these projects is dependent first on resolution of the present dispute over Turkey's control of the Euphrates River, which has often had negative impacts downstream (Kolars, 1990). For example, during the filling of the reservoir behind the Ataturk Dam in 1990, Turkey cut off the Euphrates River for 30 days, which forced Syria and Iraq to ration water and limit electricity use. The pipeline projects are also dependent on strong political support within Turkey. The new Prime Minister is less interested than his predecessor in promoting Turkey as a water broker to the region. Finally, even if political problems could be resolved, the projects would still require financing. In any of its versions, the Peace Pipeline would be a megaproject, and no country or international bank has indicated much interest in putting up the funds. Therefore, plans for the Peace Pipeline are currently on hold.

Despite current lack of interest, pipeline proposals continue to surface (Gruen, 1992). While costs are high, they may nevertheless be acceptable *in comparison with other alternative sources*, particularly for land-locked countries. Cost figures generally range upwards from about $0.40 per cubic metre, not much above present costs. The problem is that pipelines have significant economies of scale, and the lower cost estimates all depend upon large volumes. The only end-use that could absorb such large volumes is irrigation, but few irrigated crops anywhere in the region have a marginal value that makes it worth paying the costs of conventional sources, much less those of an even more expensive pipeline.

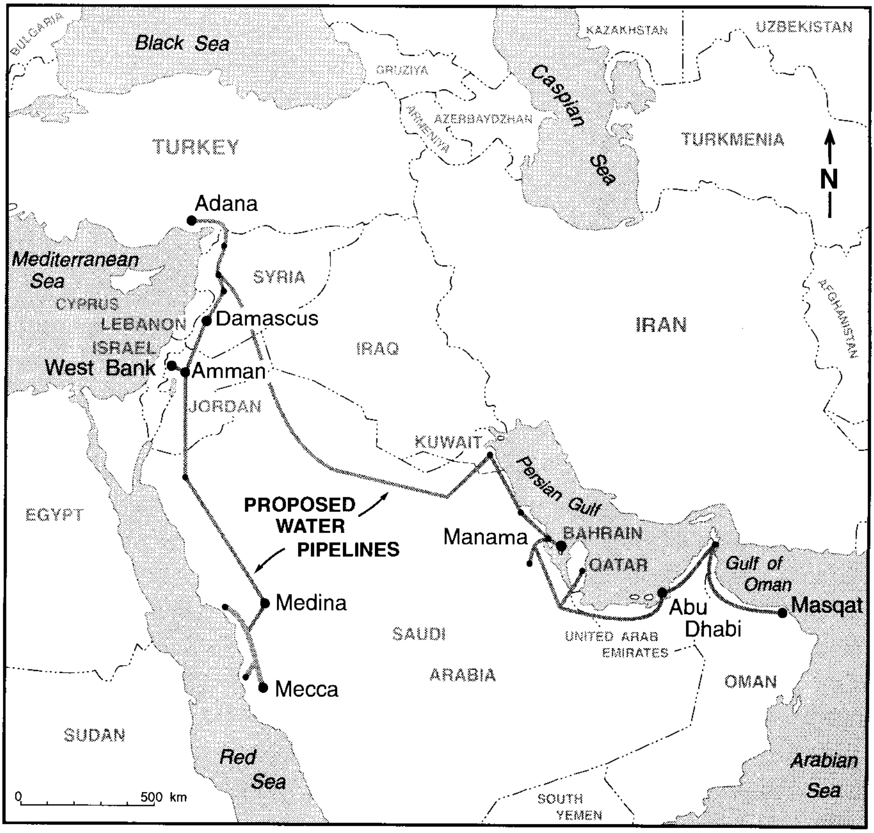


*Figure 6. Turkey's proposed Peace Pipeline*

Security of supply is an important issue among countries that have seldom known peace. The possibility that Israel, or any country, would relinquish part of its sovereignty to Turkey, which would control the flow of water in the pipeline (as would, to a reduced extent, every nation higher on the pipeline) is remote, at least without the establishment of an international authority to operate and monitor the pipeline. The options to reduce vulnerability of importing water by pipeline are similar to those of importing by sea.

Finally, the environmental impacts of inter-basin water transfers in the Middle East remain to be determined. Perhaps small in the case of tankers or medusa bags, they could be sizable at both ends of a pipeline. Little or none of the considerable discussion of the potential for pipeline projects has anything to say about environmental effects.

### *Militarization and Annexation*

In the absence of any concerted effort and action on one or more of the above alternatives, there remains the possibility that Israel would use military force to supplement its existing water supplies. As discussed previously, the water issue has been militarized in the past, and it can readily be argued that this may also be the case in the future. Thus, King Hussein of Jordan has been quoted as saying that he could conceive of few reasons to go to war with Israel, but water is one of them (Naff, 1990).

Not everyone agrees that war is inevitable in the absence of international agreement. Salih and Ali (1992, p. 46) admit that water scarcity is a constraint on development, but argue "that this hardly justifies sounding the danger bells of the possibility of regional wars over water." In their view, those who anticipate a war neglect the wide range of options ordinary people have devised to overcome or get around water scarcity. Homer-Dixon and others involved in a study of environmental change and acute conflict (1993, p.45) follow a similar approach in arguing that "water shortages will aggravate tensions and unrest within societies in the Jordan River basin," but that warfare among riparians is unlikely. They go on to quote Thomas Naff in suggesting that "internal civil disorder, changes in regimes, political radicalization and instability" are the more likely consequences of water shortages in the region.

There is some support for the theory that water had a key role in the 1982 invasion of Lebanon by Israel. Israel actually gains relatively little in terms of its entire water budget from the area it occupies in southern Lebanon, but it does give the state control of all sources of the upper Jordan and may allow the Israelis to divert water from the Litani through the use of a tunnel system which could increase Israeli supplies by as much as 500 Mcm annually (Anderson, 1988). This figure, however, is highly contentious, and others have argued the total gain from Israel diverting the river would be on the order of 100 Mcm annually. The official Israeli intention to occupy a security zone in southern Lebanon has been interpreted throughout the Arab region as a scheme to divert the Litani, and this strengthened Arab convictions that capturing and retaining control of the river is the long-term Israeli goal (International Commission, 1983, p. 12; Cooley, 1984; see Chapter VI, section E. for a more detailed discussion of the Litani River). Claims that Israel is attempting to divert Litani River water for use within Israel, however, are unsubstantiated, as noted above. These claims have also been strongly denied by the Israeli government, though the subject has obviously been under discussion at the highest levels. Thus, Cabinet Minister Ne'eman advocated remaining in southern Lebanon and controlling the country up to north of the Litani, and other Israeli officials have suggested aiding in the installation of a Christian regime in Lebanon allied with Israel so that the territory from the Litani southward can be annexed to Israel. Naff and Matson (1984) also point out that some people in Israel have argued that Litani water is the only source which will allow Israel to maintain present consumption rates and allow the government to avoid the difficult choices accompanying conservation measures.

The invasion of southern Lebanon could be similar to the acquisition of territory in the 1967 War; Israel may have gained territory for political purposes, but found that exploiting the newly available resources led to a dependence which made withdrawal extremely difficult (Calleigh, 1983). Despite the questionable validity of the claims of Israeli activity with respect to Litani waters, it is clear that Israel's invasion of Lebanon has strengthened suspicion among its Arab neighbours regarding its need for increased water resources.

## PLANNING FOR A DIFFERENT FUTURE

There are many analogies between the post-1973 experience with energy and what is now occurring with water. Both water and energy have been priced below true costs; in both cases, environmental damages occur at the production and end-use stages; both are governed by institutions geared to augment supply rather than to manage demand; and both are so widely used that many people doubt that conservation can be an effective force.

The conventional approach to supply-demand problems with either energy or water focuses on ensuring that adequate supplies exist to meet present and future energy (water) "requirements," typically expressed graphically as curves of consumption that rise with time. This perspective (with its roots in the old dogma of the insatiability of human wants -- now questioned by both ecologists and economists) leads to a supply orientation in which demand is treated as virtually exogenous to policy, a "given" which must be satisfied by ever-greater development of new sources of supply. Conservation may be considered, but generally as a way to buy the time necessary to bring new supplies on line.

The alternative approach to analysis of energy -- dubbed the "soft energy path" -- challenges conventional wisdom at each of these points (Lovins, 1977). Space does not permit even a cursory review of soft energy analysis, but at its core are three principles: (1) focus on the services provided by energy, not on the commodity itself; (2) emphasis on the quality of energy as well as on quantity; and (3) attention to the future rather than the present. Each has its analogy with water. Quality considerations are more obvious with water than with energy, but the points about services and the future deserve further explanation.

### *Demand First*

The most distinctive policy implication of soft path analysis is its emphasis on correcting apparent supply-demand imbalances from the demand side, quite the opposite of traditional energy or water policy. This approach is based on recognition that energy (water) use is only a means to an end, not the end in itself, and that the purpose of energy (water) consumption is to satisfy particular end-uses or services, such as growing a certain amount of protein or cooling a certain amount of material. The question then becomes how each end-use or service can be most efficiently satisfied.

The soft path stands the conventional approach on its head. Analysis always starts with end-uses, not sources of supply, and this reversal forces a bottom-up rather than top-down view. From this perspective, conservation and efficiency are not merely interim necessities, but the primary component of rational resource planning, the first place on which to focus attention. Each end-use is broken down (in as much detail as data permit) so that more and more efficient approaches to satisfying the service can be identified. As Lovins remarks, "in the soft path how much energy we use to accomplish our social goals is considered a measure not of our success but of our failure." Once beyond the 100 or so litres of water per person-day needed for drinking, cooking and sanitation, exactly the same is, or should be, true of water.

However, the analogy between energy and water is not perfect. Among other things: water lacks the direct linkage to thermodynamics that permits energy efficiency to be defined precisely; except for hydropower, energy supply does not vary from year to year; direct use of water is more important than indirect (unless irrigation water is ascribed to food); and water use is more highly concentrated by sector than is energy. Nevertheless, the analyses already done and referred to in Section IV.C suggest enormous opportunities to maintain standards of living, and very possibly raise quality of life, with lower consumption of water. For both water and energy, the amounts actually needed to support life, indeed to support a high quality of life, represent but a small fraction of total consumption. The lesson for both Israel and the Occupied Palestinian Territories is that the largest, safest and cheapest "source of supply" for water is likely to be found through conservation in and reallocation of existing uses.

*Backcasting*

Water is so closely connected with life itself, and with our common history in agriculture, that we tend to forget that it also has economic and ecological dimensions. Thus, we should be suspicious of projections that show increasing deficits between water use and water flows, deficits that cannot possibly be sustained. It would be more useful to recast the analysis in terms of scenarios and experiment with "backcasting" so as to determine where the system can give and the feasibility and impacts of alternative policies and reactions (Robinson, 1988 and 1990). This too is part of the experience from soft energy analysis, and a part whose virtues have been demonstrated. Traditional forecasting always showed the need for greater supplies whereas backcasting indicated the option to maintain or cut consumption. Actual energy use patterns have turned out to be much closer to those suggested by the soft path than by traditional analysis.

There are at least three other ways in which backcasting of soft water paths could work to reduce conflicts in the Middle East. First, because it is concerned not with what futures are likely to happen but with how desirable futures can be obtained, backcasting is an explicitly normative exercise. It has none of the pretensions to objectivity sometimes alleged by forecasting. This makes it an ideal partner for political science in a search for regional cooperation and accommodation. All sides see close linkages between water availability and national political and economic security. It is therefore only through the exploration of alternative futures, not simply a projection of the present into the future, that we will find ways to minimize the potential for continuing conflict.

Second, apparent conflicts between economics and environment that arise so commonly when viewed from the supply side are typically attenuated if they do not totally disappear when viewed from the demand side. With only scattered exceptions, the same policies that promote more efficient use and greater conservation also support environmental protection. For example, efficient irrigation systems reduce the risk of soil salinization, and low-flow household appliances cut wastewater flows into sewers. As environmental values become more and more important, along with concerns about the quality of water, backcasts will show degrees of flexibility in policy that are typically obscured by forecasts.

Finally, backcasting can test the resiliency of alternative scenarios to the extreme weather patterns that are typical of climate patterns in the Middle East. The impacts of weather patterns on water supply are much greater than on energy supply (where they affect mainly the volume of hydroelectricity that can be generated.) Backcasting water end-use scenarios can with relative ease incorporate loops to show the impacts of sharply different availability of water on the economy.

# VIII. GETTING STARTED: SOME RECOMMENDATIONS

> The conflict between the Palestinian people and the State of Israel, and to a lesser degree the conflict between Israel and the Arab countries has centered around the issue of land and water. . . . The academic and scientific community has a primary obligation in this regard since the alternative leaves the situation in the hands of others who are guided either by logic of power or the passions of political partisanship.
>
> (Kuttub, 1992)

The following recommendations are intended as initial steps toward reducing or alleviating the water crisis in Israel, and by so doing, reducing or alleviating both water problems and political problems vis-a-vis the Occupied Palestinian Territories. It must be emphasized from the outset that in *no way do we deny the need for Israel to be secure in its water supply*. Rather, we wish to emphasize the inefficiencies -- economic, political and institutional -- that play such an important role in Israel's water crisis, and that, if corrected, could go far toward relieving the crisis. As Lowi (1991) insists, the concept of "security" must be defined in senses broader than direct control over sources.

## ESTABLISHING PRIORITIES

This section will identify some domestic and regional recommendations by which Israel might begin to deal with the quantity, quality and geopolitical dimensions of its water crisis. Placing domestic options before regional ones is not accidental. We believe that Israel -- along with each of the other states in the region -- can and should take the initial steps toward mitigating the water crisis in areas clearly within their own jurisdiction. Regional agreements for sharing water are probably the best solution, but they are less likely to come, about and even less likely to be stable, if the participating nations do not have their own water-resource-and-use house in order.

More generally, we believe that it is appropriate to set out an ordering of priorities for resolution of water issues in Israel. We advance them with considerable confidence that they apply to other countries in the immediate region, and we suspect that they can be applied generally throughout Middle East.

- The first priority must be accorded to internal measures for attaining greater efficiency in the use of water, including both micro options aimed at the point of use and macro options in selecting among uses to be served with water.

- Second priority is also internal but focuses on developing alternative sources of supply, and particularly sources that can deliver water of lower levels of quality than are needed for drinking, cooking and washing.

- Third priority should go to intra-regional agreements and institutions for managing water, for sharing supplies, and for avoiding or mitigating quality problems.

- Only then, fourth, should consideration be given to inter-basin transfers of water and to megaprojects such as large-scale desalination.

We do not maintain that this order of priorities must be followed in every case or every locale. The Gaza Strip, for example, may already be experiencing such heavy demands on its water that only the third and fourth options have any significant potential. Many analysts would accept the ordering but argue that we should move sooner rather than later toward options in the third and fourth priority categories (for example, Shuval, 1992). Nevertheless, we believe that this ordering represents a good starting point from which each nation, and indeed each village, neighbourhood and sector, can begin gaining control of its water resource situation. We also suggest that the proposed ordering is generally consistent with two principles: (1) to focus first on options that are small in scale and locale-specific (Falkenmark et al, 1989); and (2) to start with options that are less capital intensive and only later move toward those that are more so. None of the needed steps is easy or cheap, but some are easier and cheaper than others.

One final point: Each priority level above and each recommendation below contains both technical and institutional dimensions. Emphasis here is placed on the latter. In part this emphasis is intended to offset the tendency that cuts across all literature on water to focus on technical solutions. However, in larger part it is intended to emphasize that attention to institutional issues cannot be left to the future, after a peace settlement. Any approach toward sustainable and equitable management of water will require imagination and innovation, on the one hand, together with experience and plain common sense, on the other, in institutional design and operation. As noted by Homer-Dixon et al (1993, p. 45), "The role of social ingenuity as a precursor to technical ingenuity is often overlooked."

## Domestic Recommendations

The following steps are, in our view, fundamental for Israel. They would in each case, and even more so if taken together, shift Israel onto a water strategy that would leave the nation economically stronger and politically more secure, while at the same time offering a path that is considerably less environmentally damaging than the path now being followed.

- A broad and enforceable strategy for water conservation must be the very first step toward reducing water scarcity. This strategy should, as appropriate for sector and end-use, include information programs, financial incentives, minimum efficiency standards, and regulation.
- Appropriate (marginal cost) pricing of water to encourage efficiency in allocation and use should be gradually introduced in all sectors, together with gradual reduction or elimination of subsidies to the agricultural sector. As well, low prices for initial quantities of fresh water to all households can be justified on grounds of equity.
- Remove the Water Commission from the authority of the Ministry of Agriculture, and give the commission the independence, status and structure to design and implement a more sectorally neutral water system. Responsibilities of the new commission should include, *inter alia*, water planning, water pricing and water efficiency standards.
- Encourage a shift in agricultural production patterns to reduce emphasis on water-intensive crops and increase productivity of drought-resistant and salt-tolerant crops. Grants or loans of various kinds can be provided to assist farmers in the transition.
- Encourage a shift to less water-intensive activities (eg, from agriculture to light industry). Again, incentives to promote a shift may be appropriate for an interim period.

- Enact and enforce tough pollution control laws under the control of the Ministry of the Environment, with particular attention to agricultural runoff and industrial wastewater.
- Continue the trend towards full use of recycled water for agriculture or for recharging aquifers, in parallel with: (1) investment in modern sewerage systems wherever they do not now exist (including systems for the West Bank and the Gaza Strip); (2) repair of those existing systems that appear to be leaking; and (3) establishment of clear standards for treatment and use of recycled water.

## Regional Recommendations

The conflict management literature distinguishes four main causes of conflict: a conflict over data; a conflict over incompatible interests; a conflict generated by value differences (ie, incompatible religious or cultural values); and a conflict over relationships (where values may not be in conflict, but the relationships between individuals, groups or nation-states may conflict). Only conflicts over data (for example, over "facts" of resource use or current resource availability) are clearly amenable to resolution by research. Conflicts between stakeholders who believe their interests to be incompatible may be mitigated by research that demonstrates the existence or viability of alternatives not previously taken into account. The other forms of conflict are less susceptible to reduction by the search for greater knowledge and depend rather on the search for acceptable political options.

The conflicts over water in the Jordan River basin stem from the interaction of all of these causes, and only when institutions designed to eliminate these causes are put into place will reasonable solutions be achieved. As was noted above, the difficulties in the implementation of water resource management policies with respect to international river basins stem primarily from the political unwillingness of states to enter into formal cooperative arrangements. Present institutional means for resolving these disputes in the Jordan River basin over the long term are simply inadequate to meet the needs of reducing the water problems in this region. Given the complexity of water problems in this region, it is not surprising that there has never been any official agreements on water between any Arab country -- or the Palestinians -- and the State of Israel (al-Khatib, 1992).

As a way of restarting progress toward regional negotiation and cooperation, it is worth looking at a set of recommendations from the International Conference on Water and the Environment held in Dublin in 1992 related to transboundary basins. The three relevant recommended actions were:

> (1) That countries evaluate the experience gained with existing transboundary basin water authorities, committees and commissions;
>
> (2) That countries support the further development of . . . institutional mechanisms for the co-ordination of water management within transboundary basins; and
>
> (3) That non-riparian nations promote and support the co-operation of riparian countries within a transboundary basin in the establishment of appropriate legal, institutional and operational mechanisms.

The types of institutional mechanisms that could be proposed vary widely -- from institutes which promote data sharing and joint monitoring (the simplest to develop), to water policy development agencies, to river basin management committees (the most complex, particularly if they include provisions for joint action).

In addition to the committees and institutions that have been established in various jurisdictions to address transboundary river basin issues, numerous management agreements have been signed to address specific aspects of river management. These agreements generally fall into one of two categories: those aimed at an *equitable apportionment of water supplies* (eg, the 1959 agreement between the then United Arab Republic and the Republic of Sudan, and the Indus Waters Treaty of 1960) and those which *promote joint management or exploitation of a river basin* (eg, the Columbia River Treaty of 1961 between the U.S. and Canada).

It is imperative that a regional water institution for the Jordan River basin be established that, at the very least, will act as an information clearing house and that could, eventually, evolve toward a river basin management authority. This would set the stage for a bilateral (or trilateral) agreement for sharing water resources, as was apparently included in the Camp David accords. It would also allow for the re-establishment of international negotiations for the overall design of a water system for the region, as with, for example, the Johnston Plan, and also permit the extension of such a design from surface to underground flows.

A useful point of departure for such an agreement might be found through renewal of efforts to rebuild the dam on the Yarmuk that was destroyed by Israeli bombers in the 1967 War. Naff (1990) provides ample evidence of the potential benefits of the dam. Among other things, it could provide the basis for construction of the long-proposed West Ghor canal, which would be siphoned under the Jordan River and provide a more stable water regime to West Bank farmers and communities (Shuval, 1992). While he emphasizes the need for cooperation and at least some degree of trust among nations that are still in a state of war with one another, Naff also views the dam as "an extraordinary opportunity" in the pursuit of peace (p. 165).

If trust has reached a point where shared research can be considered, a joint regional research institute on water could be developed. There is a need for a regional institute that would emphasize alternatives to the use of fresh water in agriculture, as with study of the long-term implications of greater use of recycled water and brackish water. (There are many water issues that deserve study, but this is one that is particularly important to the region and to which the joint institute could make a unique international contribution.) If such an institute is considered, it would be essential that it incorporate teams working from both technical and socio-economic perspectives.

Finally, some forms of technical and financial assistance appear to be needed. Assistance should be provided to help Palestinian farmers in the Occupied Palestinian Territories, or in the future Palestine, to install and adopt improved irrigation practices that will ensure that more of the water applied reaches the plants. As well, an infrastructure investment program is needed to provide higher quality potable water to residents of cities and towns, and, even more pressing, to carry off their wastewater. In most cases, new sewage systems will be needed, but in a few cases, repairs to existing leaky systems may be feasible. In either case, construction of sewers should be integrated with development of a wastewater recycling system that could supplement other sources of irrigation water for West Bank farmers.

## Recommendations for the Occupied Palestinian Territories

It seems inevitable that some change occur in the status of the Occupied Palestinian Territories. This is not the place to discuss the nature, size or political status of the entity that will emerge. However, while that process is evolving, there are a number of things that Israel could do to alleviate conditions for Palestinians living in the Territories and, perhaps, improve the climate for negotiations between Palestinians and Israelis.

- Perhaps most important, there should be an immediate allocation of more water to Palestinians in the Occupied Territories, partly as a gesture of good will and partly because it will force some cooperation between Israeli authorities and whatever Palestinian authority may emerge from the present peace negotiations. This water would be released for agricultural or other economic developments, not only for household and urban use. (As indicated above, the Israelis have generally made water available as needed for the latter uses, but have not permitted the former to expand since 1967.)
- Israeli officials, notably in the Water Commission, should reduce the level of security attached to water data and make them more widely available. (Over the past year, steps have be taken to this effect.) To the extent possible, the data should be released in both processed and unprocessed form. In addition, ways should be found to ensure that water data are as available to Palestinians as to Israelis, something that is not currently the case. At the First Israel-

- Palestinian International Academic Conference on Water in Zurich in late 1992, the Truman Research Institute at the Hebrew University of Jerusalem pledged to ensure that data sharing became a reality. That pledge should be acted upon, with, as appropriate, the assistance of other nations and international agencies.

- Occupation authorities should explicitly recognize a joint concern for water use between the two peoples, and they should accept some degree of joint planning and management of shared water resources. Implicitly, of course, this would amount to a statement of Israeli dependency on water originating in the final Palestinian entity, but this is a matter of fact and would merely establish a basis from which discussions about sharing, likely with some form of compensation, could begin.

- Once that joint concern and a strong role for Palestinian participation are accepted, a number of actions are indicated, among them:

  - Improvement of the quality of water in the Lower Jordan (below Lake Kinneret) which Palestinian farmers currently find too saline for most crops.

  - Planning and construction of water and sewage systems throughout the West Bank and Gaza, with most if not all the sewage reclaimed for use within the Territories. (Such a general position should not preclude exchanges of either water or reclaimed sewage when that is more efficient than totally independent systems.)

- Given recognition of Palestinian responsibility to manage water, Israel should indicate that those aquifers on the West Bank that both rise on the West Bank and flow eastward rather than westward or northward will henceforth be managed by and for the Palestinian community.

- Israel should reduce if not cease pumping from wells to the west of the Gaza Strip in order that flow rates in the aquifer supplying that area can increase. If nothing else, Israeli justification for pumping from these wells (at the up-flow end of the aquifer) is totally inconsistent with its justification for pumping from the Mountain Aquifer (at the down-flow end of the aquifer) (al-Khatib, 1992).

# IX. CONCLUSIONS

> The current Middle East peace process provides Israel, for the first time in its history, with a real opportunity for the recognition of its entitlements to both existence and land by the Arabs. Of course, a by-product of this would be the acknowledgement by Israel's neighbours of its entitlement to a fair proportion of the area's waters. On equal footing, the peace process provides the Palestinians, too, with their first opportunity for national recognition by Israel. Among national rights, of course, are entitlements to natural resources such as water. The sticky point comes in deciding who is entitled to how much of the area's limited water resources. Obviously this question is not limited in scope to Israel and the anticipated Palestinian entity, but applies further to the other involved countries in the area.
>
> (Zarour and Isaac, 1992, p. 3)

This monograph has examined the economic, ecological, and political dimensions of Israel's water problem and developed a set of alternatives for resolving - or reducing the extent of - these problems. What is clear from the discussion of these issues is that the water "crisis" is actually a set of three problems; water quantity; water quality; and the geopolitics of water. What is also clear is that these problems are interrelated; possible solutions must address all three. To complicate matters even more, some of the least costly alternatives are also the least palatable; economic efficiency often conflicts with security objectives or with Zionist ideology and history.

In areas of water stress, which is clearly the case for the three main riparians of the Jordan River, only those approaches that treat quantity and quality issues together, and that avoid economics-ecology conflicts can be taken seriously. This requires coordinated management, and especially demand management. Even if the countries of the region are relatively careful in their use of water by international standards, they are far short of either the technical or the economic potential to greatly enhance water supply. And, given expected levels of population and aspirations for economic development, they have no alternative but to exploit the potential for demand management fully. In short, conservation and efficiency in the delivery and use of water are likely to be the most important "sources of supply" in the Middle East. They are also likely to be the cheapest and the least environmentally damaging sources.

Some people view today's water problems in Israel, indeed throughout the Jordan Valley, as reaching crisis proportions; others argue that those problems are merely the latest version of a chronic situation. Depending upon the particular aspect of the problem under question, either approach can be justified. However, it is clear that Israel has a crisis in water management. That crisis has both internal and external dimensions. It can be resolved only by putting its own water management house in order and by accepting means for equitable sharing of water resources with Palestinians and Jordanians.

Finally, one cannot ignore that the politics of water in the region are being played out in a very international context. With only a few exceptions, every nation in the Middle East depends on water supplies in which at least one other nation -- and commonly an upstream nation on a river or an up-flow nation on an aquifer -- has a significant interest. This explains in part why some nations which are usually antagonistic to Israel are rather more moderate in the case of water. Whatever Syria, for example, may claim about limiting Israeli rights to Jordan River water could, later, be applied by Turkey to limit Syria's rights to Euphrates River water.

In our view, the quotation from Zarour and Isaac that is cited at the head of this final chapter is the best single statement of which we are aware of the importance of water for both Israel and the Occupied Palestinian Territories, and for both the present time and the future. We share their perspective, and we share the statement's implicit optimism. Around the world, water use is growing faster than population. That future is simply not available to most people in the Middle East, and most certainly not to those who share the Jordan River basin. In terms of the peace process, therefore, water resources must be both means and ends.

- end -

WATER IS FAR FROM A SIMPLE COMMODITY;
WATER'S A SOCIOLOGICAL ODDITY.
WATER'S A PASTURE FOR SCIENCE TO FORAGE IN;
WATER'S A MARK OF OUR DUBIOUS ORIGIN.
WATER'S A LINK WITH A DISTANT FUTURITY;
WATER'S A SYMBOL OF RITUAL PURITY.
WATER IS POLITICS, WATER'S RELIGION;
WATER IS JUST ABOUT ANYONE'S PIGEON.
WATER IS FRIGHTENING, WATER'S ENDEARING;
WATER IS MORE THAN MERE ENGINEERING.
WATER IS TRAGICAL, WATER IS COMICAL;
WATER IS FAR FROM THE PURE ECONOMICAL.
SO STUDIES OF WATER, THOUGH FREE FROM ARIDITY;
ARE APT TO PRODUCE A GOOD DEAL OF TURBIDITY.

(KENNETH BOULDING, 1964)

# APPENDIX

(Adapted from: Shuval, 1992).

## CLAIMS, COUNTERCLAIMS, FEARS AND CONCERNS

Shuval (1992) details some of the claims and counterclaims as well as the real and perceived fears and concerns of the two sides of the dispute over the Mountain Aquifer.

### Palestinian Claims and Concerns

1.The Palestinians claim that the flow of the Mountain Aquifer -- which is fed by rainfall over the West Bank, and 90% of which is currently extracted from deep wells mainly within Israel -- should be allocated for their use, and that Israel's much criticized, long term over-pumping of the aquifer is a serious threat to the Palestinians' future essential water reserves.

2.The Palestinians are concerned that Israel, because of increased demands for development from the mass immigration of Jews from Russia and other countries, will extract more water from the Mountain Aquifer, depriving the Palestinians of an equitable share. Some Arab leaders have requested that authorities in these countries stop the emigration of Jews to Israel.

3.The Palestinians claim that the Israel Civil Administration has effectively frozen Palestinian utilization of water sources in the Occupied Palestinian Territories, allocating insufficient amounts for urban and industrial use and practically no water for increased agricultural development or to meet the needs of a growing population. They claim that during the period of occupation, Israeli authorities have developed new water supplies in the Occupied Palestinian Territories and have allocated significant amounts of water for agricultural and urban use for new Jewish settlement in the areas. The Palestinians claim that this violates the Geneva Convention and that Israel misuses its authority as the "belligerent occupier." Particularly aggravating to Palestinian villagers is the perception of wasteful Israeli water use and landscape practices which often include the irrigation of lawns and the construction of swimming pools.

4.The Palestinians claim that the process of drilling new deep wells within the Occupied Palestinian Territories is depleting the aquifer, and traditional springs and shallow wells used for domestic and agricultural purposes in neighbouring Palestinian communities are drying out. They claim that Israel's pumping of groundwater near the Gaza Strip has caused the severe salination of the wells in Gaza. Even when the Israeli authorities supply water to the communities that lost their original wells or springs, the cost to the villagers is increased, which is viewed by Israelis as an appropriate method of controlling demand.

5.The Palestinians claim that in all new water projects developed by Israel in the Territories and which serve Palestinian communities, key controlling elements such as regional reservoirs, valves and control points are located within Jewish settlements, which is viewed as a method of domination.

6.The Palestinians fear that, even if a peace settlement is achieved, and an appropriate Palestinian entity established, the division of the very limited shared water resources will leave them with insufficient amounts of water to accomodate population growth and the resettlement of the Palestinian diaspora with the required urban, industrial and agricultural development.

7.In the event of major regional projects to import water to the region, there is concern and fear that Israel will retain practical and political control over all water supplied to the Palestinians and Jordan. There is equal concern that other nations of the region, which may supply additional water or allow water pipelines to pass through their territory, will use the water supply lines for purposes of political control, as Turkey did in the case of the Iraqi oil pipelines during the Gulf War of 1990-91.

8.In general, the Palestinians claim the priority rights to complete and total control of "Palestinian" water (the Mountain Aquifer) and suggest that complicated schemes to import water from other nations or to desalinate seawater be allocated to Israel which, in return, should forgo claims to the local, easily accessible, "Arab" water sources.

## ISRAEL'S CLAIMS AND CONCERNS

1.Israel claims that it has legitimate historical riparian rights to the Mountain Aquifer, based on the principle of prior use. Major portions of this aquifer flow naturally into its territory and have been developed at great expense and fully utilized over the past 60 years.

2.Israel is concerned that if the Palestinians achieve autonomy or independence, they will gain physical control of the Territory, and carry out their claim that all of the water of the shared Yarkon-Tanninim Aquifer (Mountain Aquifer) that is derived from rainfall within the West Bank (estimated to be about 80 percent of the total flow of the aquifer) be allocated exclusively for their own use. This fear is compounded in Israel's eyes by Palestinian goals of returning the Palestinian diaspora to any independent entity which is established.

Some Israelis claim that if there is a major increase in pumping from the aquifer, it would mean a drastic reduction of Israel's most important, high-quality, source of drinking water. It might mean a reduction of Israel's current utilization of that aquifer by some 300 Mcm per year, cutting off of the drinking water supplies for some 3 million people. Needless to say, this would be totally unacceptable to Israel.

3.Even if an equitable agreement is achieved on the division of the waters of the Mountain Aquifer between Israel and any future Palestinian entity, there is serious concern about the possible degradation of the quality of the water of the shared Mountain Aquifer as a result of inadequate monitoring and control of urban pollution, wastewater and toxic agricultural and industrial wastes in the West Bank. This could cause serious pollution in the highly susceptible karstic limestone aquifer, making the water unfit for human consumption.

In 1990, General (Reserves) Raphael Eitan, at that time the Minister of Agriculture of Israel, published a full page ad in the Israel press (Jerusalem Post, August 10, 1990) expressing many of the above concerns, and declaring that because of the water issue alone, Israel can never give up the physical control of any of the Occupied Palestinian Territories since they are absolutely essential for the preservation of the country's vital water resources. He cited both the threat of the diversion and/or overpumping of water vital to Israel and the danger of environmental pollution of the shared aquifer.

4.There is also concern that unregulated overpumping of the Mountain Aquifer in the West Bank could lead to a serious lowering of the water table with the resulting danger of the saltwater intrusion and irreversible damage to the shared aquifer which could be a real threat to both partners.

5.Palestinian calls for the ending of immigration to Israel from Russia and other countries is seen as an unacceptable interference in Israel's internal affairs. Israel views unrestricted immigration of Jewish refugees as the foundation stone and raison d'etre of the country and any demand to restrict immigration is seen as unacceptable.

6.Israeli officials maintain that Palestinians have not been deprived of the use of needed water. They cite the construction of new water supply pipes, introduced by Israel since the end of Jordanian rule in 1967; the granting of permits to the Palestinians to drill some 40 new deep wells; and the importation of water from the National Water Carrier to increase the water supplies to Palestinian cities and villages in the Occupied Palestinian Territories. According to Israeli claims, total water supply and per capita use in the Occupied Palestinian Territories has increased significantly during the period of the Israeli administration. Israeli hydrologists say there is limited connection between the ground water in Gaza and Israel and that the salination of wells in Gaza is solely the result of years of overpumping by the Palestinians prior to 1967. Israel also points out that many Palestinian claims of wells and springs drying up coincided with the 1988-91 drought period and may have nothing to do with Israel's water development projects.

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