WATER WISDOM:

Preparing the Groundwork for Cooperative and Sustainable Water Management in the Middle East

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PREFACE

For too long the professional literature characterizing the conflicts between Israelis and Palestinians over water issues has suffered from the twin transgressions of excessive generalization and alarmism. Books and articles did not engage experts on the two sides and encourage them to systematically identify those areas about which they agree and disagree. There has been an unfortunate shortage of focused academic frameworks in which to explore pragmatic solutions to overcome existing controversies. Only when differences are clearly mapped can they can be addressed. Indeed, sometimes, when the two positions are laid side-by-side, there is less discord than originally anticipated. At the same time, there has been no shortage of academics, politicians and diplomats who broadcast disquieting and defeatist scenarios about the conflict that emerge from the region's growing water scarcity. "*The next Middle East war will be fought over water*" is a commonly heard platitude. But we believe this perspective to be simplistic and detached from the actual dynamics in the field. As friends and colleagues who have worked together in the field of water science and policy for over a decade, we are more optimistic.

The Palestinian and Israeli experts who join us in this book agreed to increase the level resolution regarding the water management challenges that they face. Each of the central areas that make up the heart of the "water conflict" is addressed in a chapter by an authority from each side. These dispassionate "twin" analyses enable us (and readers) to better consider the specific areas of dispute and agreement. Our work as editors and mediators who seek to say something constructive and new was made much easier after we convened a gathering of the authors in Amman Jordan in May, 2008. Draft chapters were presented and an informal, but intense practical discussion ensued about the implications of the two positions. Based on the dialogue and the ideas which arose, we offer a series of summaries on each subject that constitute a consensus about the present situation and what a comprehensive accord needs to contain so that water might constitute a catalyst for cooperation rather than conflict. In the final chapters, common visions of cooperative institutional and management frameworks are set forth by Palestinian and Israeli experts in single chapters about the role of NGOs in resolving water conflicts and joint management frameworks. Given their long-time involvement in the field, discussions in Amman benefited from the individual perspective of retired British diplomat, Robyn Twite and Professor Hillel Shuval.

An underlying theme of all chapters in this book is that while there are many acute hydrological problems, solutions are at hand. Technological alternatives, models for joint water management and public policies exist. There is no reason why an adequate supply of high quality water cannot be available to both Israelis and Palestinians. This book offers a blueprint for cooperation, pragmatism and ultimately sustainable water management. From stream restoration to ground water management, from the Jordan River to the aquifer in Gaza, from desalination to wastewater reuse – this book provides an update of where we are – and where we might go.

Resolving existing Palestinian/Israeli tensions over water issues must begin with a focus on water allocation and supply. The average per capita consumption of 50 liter per day in the West Bank and the 13 liter per day per capita (suitable for drinking purposes) in Gaza is unacceptable places constant pressure on the stability the socio-economic future of the Palestinians. Without a sufficient and safe supply of water it will be difficult to ensure a stable future for the emerging Palestinian State.

Finding additional water sources constitutes a core political issue in the final status negotiations for Palestinians and Israel is highly aware of this. Indeed, the "Oslo Accords" established only an interim arrangement for water allocations, leaving ultimate division of shared water resources as an issue for negotiations in the final accord. This was reiterated at the 2007 Annapolis peace talks. Palestinians have consistently held that water rights should be resolved according to principles of international law which presumably would guarantee sufficient quantities and grant sovereignty to Palestinians to utilize and control their water resources. Given the amorphous nature of existing international principles, and such concepts as the "reasonable and equitable share of water resources" or its "beneficial uses" -- it is not clear whether international legal instruments provide sufficiently clear direction for the kind of resolution that a final agreement will need to provide. Negotiations will need to take a more pragmatic approach to water quantities, as they did in the peace accord between Israel and Jordan.

The growing gap between the supply and needs of Palestinian communities makes additional conventional and non-conventional water resources essential. The availability of low-cost desalination changes the "zero-sum game" dynamics that characterized discussions in the past. The 1995 agreement on water between Israel and Palestinians was made before desalination became a central part of Israeli water supply strategy. But the change constitutes an historic opportunity. Effluent reuse, water conservation and efficiency measures are already part of present accepted practices and must be expanded.

Water quality issues are likely to be less divisive as the sides seek a final accord. The lack of sanitation services, poor management of sewage and solid waste, overzealous application of fertilizers and pesticides along with the over-extraction of water contribute to the polluting of the springs, streams and aquifers of both parties. This chronic pollution has led to the decommissioning of many wells taking its toll on the limited water resources in Israel and Palestine, The environmental damage serves to exacerbate existing gaps between water supply and demands. Accordingly, joint management frameworks constitute a "win-win" dynamic and offer an opportunity to enhance the sustainable development and protection of water resources on both sides of the border.

Of paramount interest for both sides is the matter of sewage and infrastructure. Wastewater treatment is an essential element in alleviating pollution to Palestinian water resources, improving their quality of life and expanding the available water for irrigation and stream restoration. But sewage treatment is not only a technical/engineering challenge, but needs to be addressed in a holistic approach that takes into consideration, institutionalization of wastewater treatment, technologies and system maintenance as well as reuse strategies for agriculture along with promulgation and implemention of regulations. In Israel, beyond continued progress in reducing discharges from factories and municipal sewage systems, nonpoint sources of pollution, especially from agricultural and urban storm runoff have not been systematically addressed heretofore. Gas stations have also emerged as a major source of groundwater contamination.

In short, there is the full menu of water issues that are addressed in the chapters of this book. We have tried to put together a volume that is both scientifically precise, but accessible to readers who are not hydrologists are scientists working in the field. The importance of cooperation is not uniform for all issues. Some hydrological challenges require complex and politically charged joint management strategies, while for others, coordination in a general sense is sufficient. Yet, none of the Palestinian and Israeli water problems are insurmountable. What is required is political commitment, economic resources, creativity, flexibility and good will.

Alon Tal
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Summer 2008

1. Characterizing Water Resources

In these opening two chapters, a review of the Israeli and Palestinian water resources are presented, offering an introduction to their quality and potential for their expansion in the future. Disparities between the objective quantities and quality are minimal allowing for a common basis for the future consideration of management challenges.

Israeli Water Resources – an Introduction

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I. Introduction

While Israeli and Palestinian management of water resources can constitute a politically charged issue, there are some objective facts about which the sides generally agree. A brief overview of the water resources available to each side and the major environmental threats facing them offers an important foundation for any analysis about the full range of transboundary water issues considered in this book. This chapter offers a brief description of the hydrological reality shared by Israelis and Palestinians as well as several salient disparities. It will attempt to characterize the basic quantities and qualities of water resources, past, present and future plans to develop resources and the competing claims of sovereignty held by each side. This background is important for understanding subsequent discussion of specific issues associated with coordinated water management. The chapter opens with a description of Israeli water resources, continues with a description of Palestinian water resources and then concludes with a summary of the areas of agreement and disagreement between the two sides.

II. Water Resources – the Israeli Perspective

Precipitation

Climatically, Israel and its neighbors are located in areas that are identified as water scarce regions. Figure 1 shows the enormous variation in rainfall that characterizes the relatively modest distance of 300 kilometers from Israel's northern tip near the Lebanese and Syrian border to its southern most point, at the Gulf of Aqaba. Some 20% of the water potential lies in the south of the country with 80% of the precipitation occurring in the north. Accordingly, most of the country can be classified as "drylands" by international standards (under 500 mm rainfall per year). The general scarcity of rain and its spatial imbalance is exacerbated by its temporal asymmetry – with virtually no precipitation occurring during a dry season that runs over half the year between May and October.

Like many Mediterranean climates, Israel has always been subject to drought cycles, but this may be growing worse. The United Nations' International Panel on Climate Change has projected general drops in rainfall for the region. Yet, during the past sixteen years, average precipitation has dropped from 1,350 to 1,175 MCM suggesting that climate change may already be exacerbating water scarcity. Indeed, in 2008 Israel's Water Authority reported that the probability of four consecutive extreme drought years occurring as they have since 2005 is only 2%

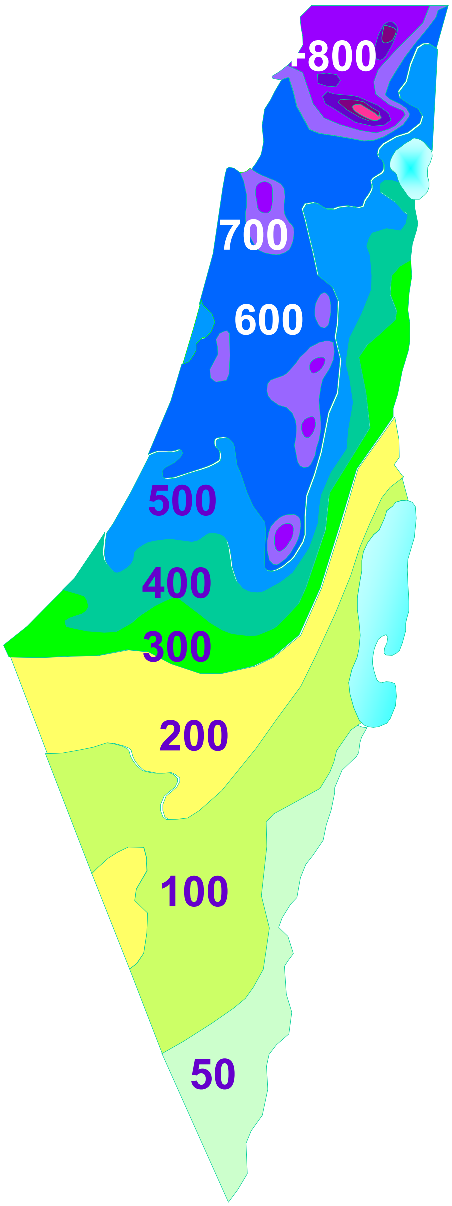

Figure 1: Israeli and Palestinian - Average Rain Gradient (in mm rain/year)

Source: Israel Hydrological Service

When Israel received its independence in 1948, water managers working for the government mistakenly overestimated that the available renewable resources would reach 3,500 million cubic meters (MCM) a year.* As appears in figure 2, Israeli's governmental Hydrological Service that for many years set the figure for rain-supplied renewable water sources in both Israel, the West Bank and Gaza at closer to half of that – some 1,355 MCM has issued new estimates reflecting the climatic change. A full 95% of this amount is utilized for agriculture, industrial, domestic and as well supporting ecological systems. This figure does not include an additional 300 MCM that is recycled as waste water reuse, nor over 100 MCM that now enters the system as desalinized water consumption and irrigation. At the same time, a growing number of wells have been classified as "too contaminated" for use of any kind.

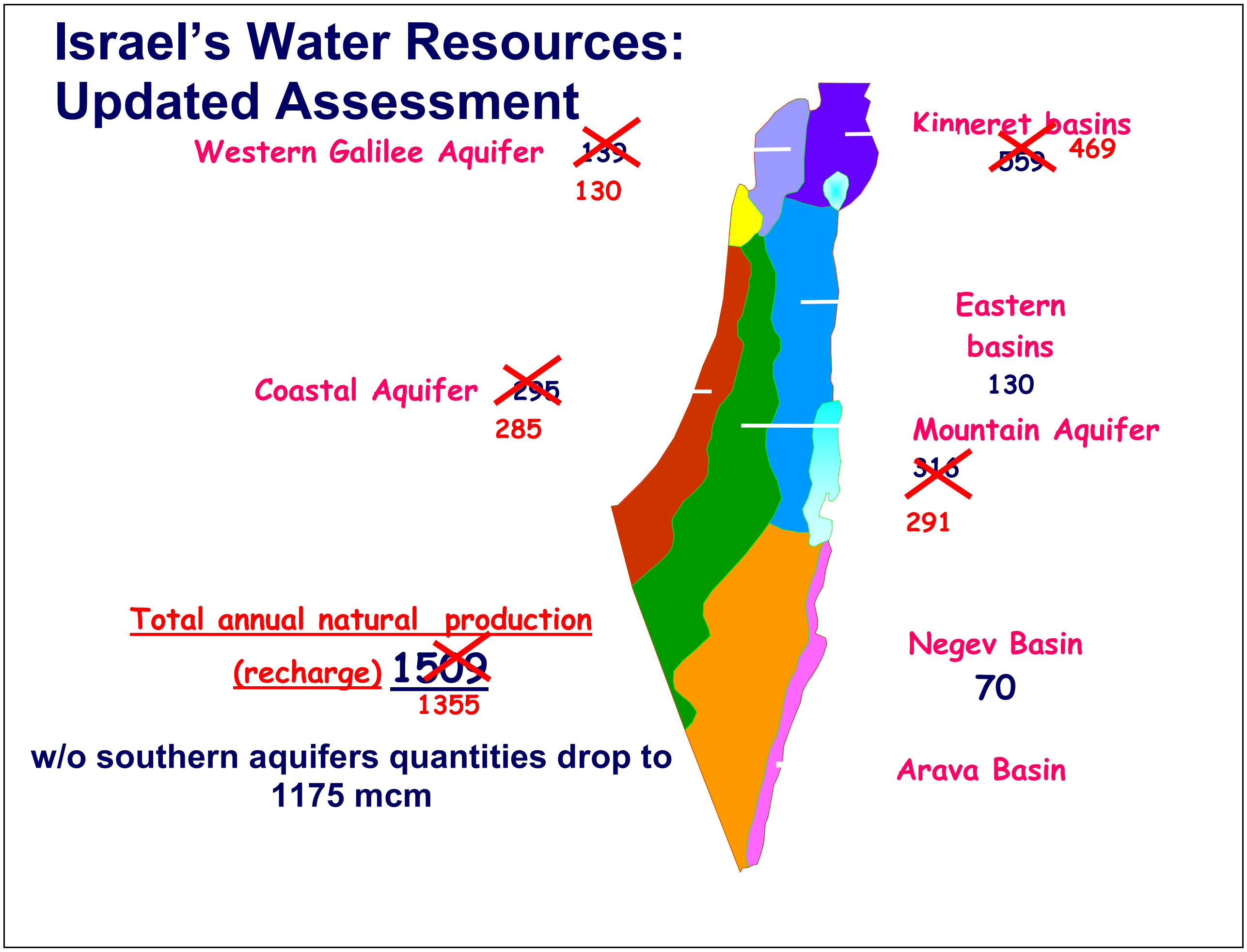

Figure 2: Israeli and Palestinian Freshwater Resources (in–MCMs)

Source: Israel Water Authority, 2008

**In this volume, water will be presented metrically by cubic meters or m^3 – the equivalent of 1000 liters. Hence 100 million meters or (MCM) the fundamental unit of accounting is actually 100 billion liters of water.*

Figure 2 maps out the main freshwater resources which might be utilized by the two sides: These include three primary water bodies: Lake Kinneret (or the Jordan River watershed), the Coastal Aquifer, and the Mountain Aquifer, which is in fact a series of connected groundwater systems. Each one of these bodies will be characterized in greater detail in future chapters, and will only be described in a cursory fashion in the present context. In addition, there are several smaller regional resources of variable qualities located in the Upper Galilee, Western Galilee, Beit Shean Valley, Jordan Valley, the Dead Sea Rift, the Negev and the Arava. Israel's two "seas" (the Mediterranean and the Red Sea) increasingly provide water for desalination while the Dead Sea remains largely a recreational and historic resource.

Lake Kinneret (The Sea of Galilee)

Lake Kinneret is the only natural surface reservoir in the region and holds the distinction of being the lowest fresh water lake in the world. Known to Christians throughout the world as "the Sea of Galilee", much of the evangelical activities ascribed to Jesus in the New Testament took place around the Kinerret and it is the site of many important religious sites for Jews as well. Hence, the lake is not only a hydrological resource, but a critical recreational and spiritual one as well. The Kinerret itself is not exceptionally large, with a width of only 22 kilometers and a total surface area of only 168 $km^{2.}$ At its deepest point the Kinerret reaches 43 meters and only has an average depth of 24 meters. The lake continues to be a productive fishing ground and it provides a range of catch, most notably the indigenous "St. Peter's Fish" and a variety of bass.

For some forty years now, Lake Kinerret has served as Israel's national "reservoir", but only a fraction of its potential 4.3 billion cubic meter volume can be utilized during any given year, as excessive drawdown makes the lake vulnerable to salination from underlying saline flows. Accordingly, a "red-line" has been established in the lake, whereby water can not be pumped when the lake falls below 215.5 meters below sea level. (This is a relatively new "minimum" water level; the older, more stringent, 213 meter level was amended in a controversial decision during a recent drought.)

Lake Kinerret lies at the bottom of a catchment area that not only includes the Galilee and the Golan Heights, but also Lebanon and Syria. Some 800 MCM of water naturally flows into the lake, primarily via the Jordan river or its tributaries. A substantial portion of these waters (roughly 300 MCM) is lost to evaporation. Recent change in precipitation are already reflected in the Kinerret's water supply. While the lake used to provide 500 MCM to Israel's water network during the 1960s, as of late the average amount utilized is closer to 320 MCM. Figure 3 shows the flux in water levels and the general tendency of government water managers to avoid pumping below the "red lines" below which it is thought that hydrological damage from salinization begins.

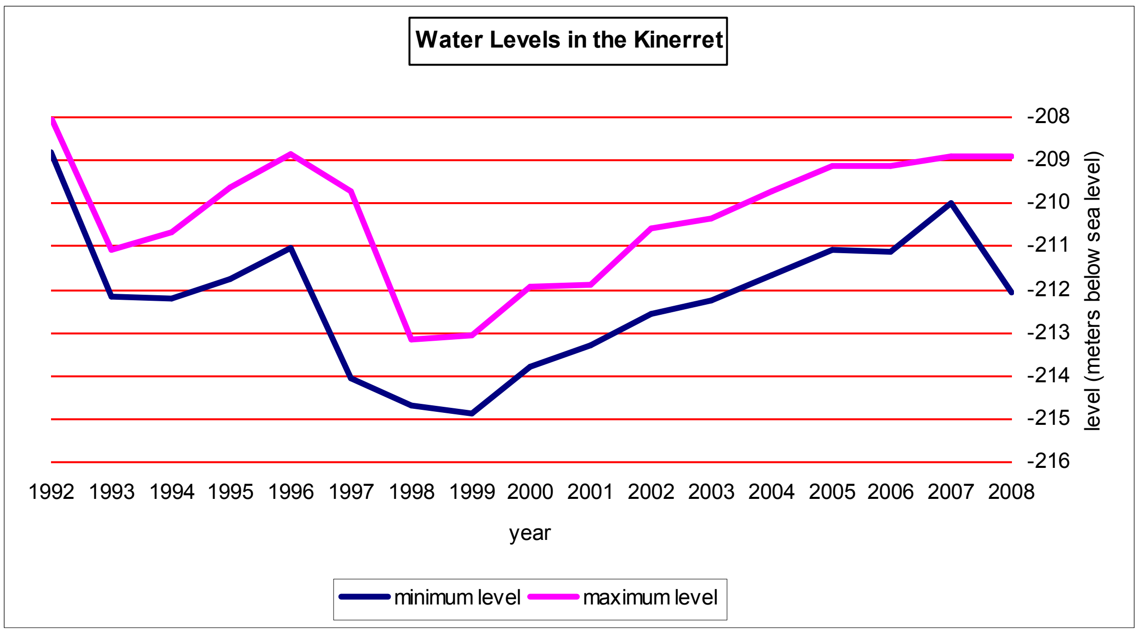

Figure 3: Water Levels in the Kinerret

Source: Kinerret Administration, 2008

The precipitous drop in the water levels in the lake that have followed the recent drought have pushed the water beyond these red lines. (See figure 4) During the spring of 2008 a national campaign was launched, encouraging water conservation, lest water levels fall below the "black lines" where hydrological damage is expected to be irreversible.

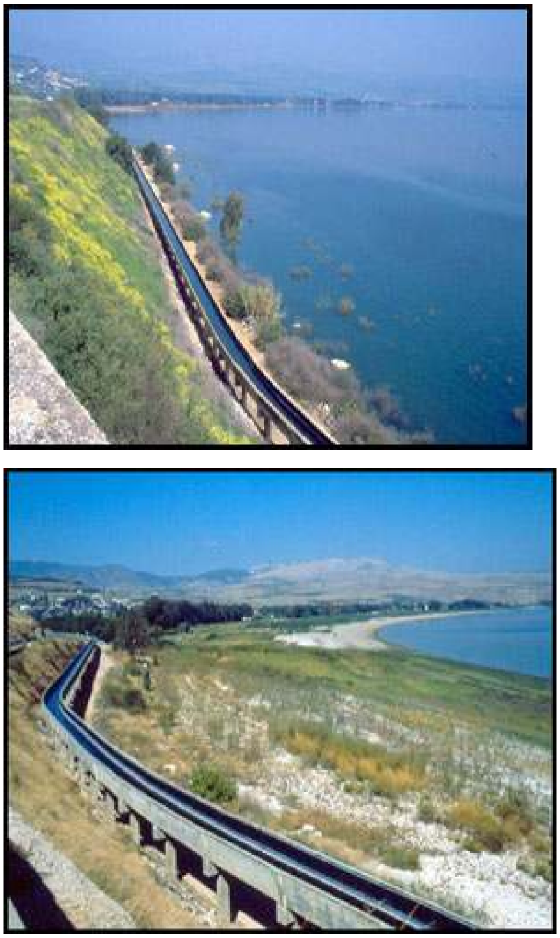

Figure 4: Lake Kinerret before and after recent drought years (spring 2008).
Source: Society for Protection of Nature in Israel
(The canal on the banks contains flow from salty springs, diverted to the southern Jordan River to improve water quality).

In some respects, the water quality in the lake has improved during the past forty years due to the diversion of most of the local saline streams which historically brought the salinity of the lake to average concentrations of 389 milligrams of chloride per liters. Today, chloride levels are almost half that, holding steady at 200 mg/l. Yet, due to the drainage of wetlands upstream in the Huleh Valley and intensified economic activities in the water shed, there is also a steady increase in nutrient loadings, raising the specter of eutrophication in the lake. In recent years, the rate of point and nonpoint source discharges have been reduced, due to the intervention of a Kinerret Authority, which catalyzes a variety of pollution prevention and enforcement activities.

The Mountain Aquifer

With a recharge area that largely lies in Palestinian territories, and wellheads that are for the most part located inside of Israel, the "Mountain Aquifer" is undoubtedly the most contested of the water resources shared by Israelis and Palestinians. Geologically, the aquifer is dominated by carstic, limestone formations, and hydrologically it is characterized by great depth, (averaging 250 meters) and relatively rapid flow. In fact, the "Mountain Aquifer"is something of a misnomer – and the term in fact refers to three, separate, but contiguous basins:

- The "Yarkon Taninim" Aquifer, which contains about half of the total water in the aquifer, which flows from the eastern Judaean/Sumarian foothills to the coast. This aquifer provides about a fifth of Israel's fresh water, typically at a very high quality.
- The Eastern Aquifer which discharges in the Beit Shean Springs, lying almost completely in the West Bank and naturally containing, somewhat more saline waters.
- The North-Eastern Aquifer, where natural replenishment reaches some 130 MCM of water, about half of which is brackish.

The Coastal Aquifer

The Coastal Aquifer runs the length of the Mediterranean - from the Haifa "Carmel " region all the way down through the Gaza Strip. (See figure 1) With the water table lying a mere thirty meters below an unsaturated zone of sandy soils, the aquifer serves as an excellent storage facility. Moreover, the filtration provided by the sands tends to contain the spread of pollution, making most contamination a "localized" phenomenon. Typically, natural recharge is set at 250 MCM, although recent figures are slightly lower (233 MCM). This figure, however, does not include waters from the National Water Carrier and advanced treated effluents that are intentionally injected into the aquifer as well as irrigation return flows which together make up a volume of almost equal size.

Testing done during the 1930s suggest that the aquifer originally enjoyed extremely high quality water (50-100 mg/liter of chlorides and less than 10mg/liter of nitrates). Figure 5 shows just how dramatically this profile has changed. Today, the coastal aquifer reflects the cumulative impact of decades of environmental insults, exhibiting continuous deterioration during the past fifty years. In many sections of the aquifer, it takes roughly a year for pollutants to seep down a distance of one meter, linking today's contamination with activities that took place during the 1970s. The steady rise in nitrates produced by sewage, fertilizers and industrial wastes reflects this process. Indeed, without appropriate pretreatment and waste water infrastructures Israel's extensive municipal effluent recycling is responsible for contamination by a range of industrial solvents including benzene, toluene as well as metals.

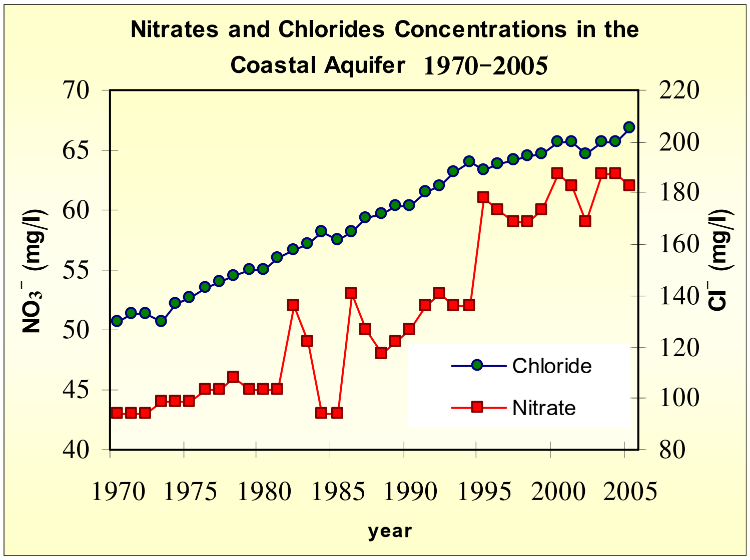

Figure 5: Nitrates and Chlorides Concentrations in the Coastal Aquifer

Source: Israel Ministry for Environmental Protection (2002) and Israel Water Commission (2005-6)

Yet, the most prominent problem historically has been that of overpumping. The safe yield of the aquifer has been set at around 275 MCM depending on the condition of the aquifer. Yet, as shown in figure 6, pumping rates were typically higher, and sometimes far higher. This lowered the level of the water table, in some places by as much as 6-10 meters. The resulting vacuum is slowly filled by sea water. Moreover, the natural flow of water to the sea, which naturally flushes out salts and minerals from the aquifer, is interrupted. By the mid-1950s Tel Aviv's wells had already grown too salty for drinking and over the years over ten percent of wells along the coast have been decommissioned. Since the 1950s, average chloride concentrations increased to roughly 200 mg/liter, reflecting average annual increases of 2.4 mg/liter. In some areas, such as the Gaza Strip, concentrations are far higher.

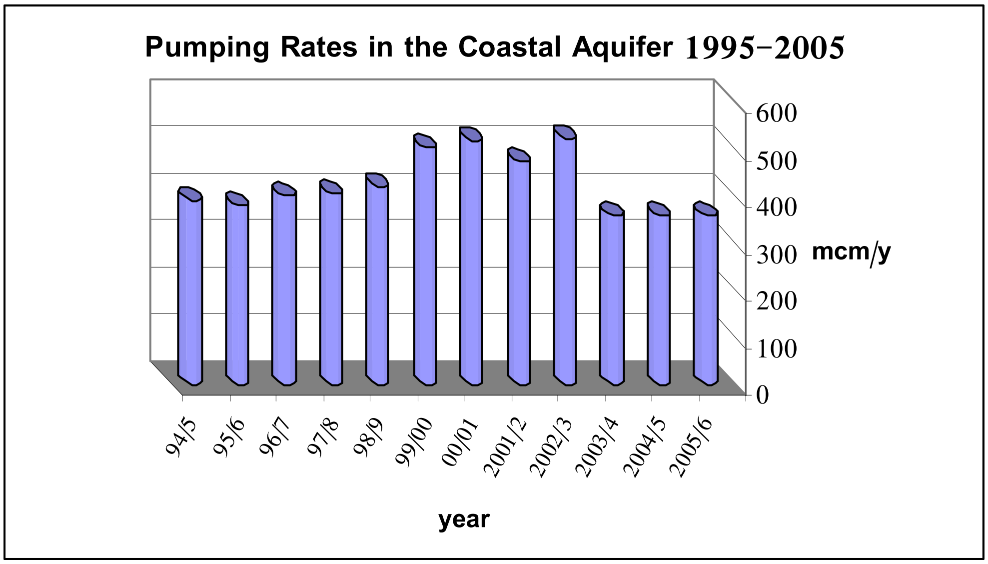

Figure 6: Pumping Rates in the Coastal Aquifer over 30 years

Source: Israel Hydrological Service (2002) and Israel Ministry of Environmental Protection, (2006)

This twin pathology of increased nitrates and salinity levels is not limited to the Coastal Aquifer and can be found in many of the other smaller groundwater systems such as those in the Jezereal Valley, the Arava, and the Western Galilee.

Additional Water Sources: Israel's Water Management Strategy

The history of Israel's water management is best characterized as a relentless pursuit of expanded resources. With the steady, geometric growth in population, per capita water availability by definition faced continuous decline. Efforts to reduce demand through improving efficiency in agriculture, or water conservation promotion ameliorated the problem. But the centerpiece of Israel's management strategy was aggressive and creative policies to develop new sources of water. This is as true today as it was during the 1950s. Table 1 contains projections by Israel's Water Commission regarding anticipated water demand in Israel alone.

Table 1: Water Supply and Demand - Israel 1998-2020 MCM/year

Year	Population (Million)	Surface Water	Groundwater	Brackish Water	Treated Effluents	Desalination	Total
1998	6.0	640	1050	140	260	10	2100
2010	7.4	645	1050	165	470	100	2430
2020	8.6	660	1075	180	565	200	2680

The National Water Carrier: The initial challenge involved bridging the disparity of almost two orders of magnitude in rainfall between the 'water rich Galilee" in the north and the water poor Negev in the south. Almost from the advent of Jewish settlement in Palestine, establishing a "carrier" to transfer water to arid regions was an amorphous, but important part of the Zionist vision. In the 1950s, the new nation made a prodigious investment in the National Water Carrier, which since 1964 brings water from the Kinerret Lake in the north to the south of Israel as part of a national grid.

Wastewater Reuse: By that time, water managers had already approved an aggressive strategy of waste water reuse. Israel was among the first countries to recognize the potential of recycled municipal effluents as a source of water for its citizens. As the country's population grew exponentially, the amount of sewage produced began to exceed the carrying capacity of the existing infrastructure. Until the 1950s, it had been based largely on septic tanks, with relatively little central sewage collection systems and practically no treatment facilities. The resulting contamination of water resources, the sea, and the attendant mosquito infestation created a "push" to compliment the "pull" of creating an additional source of water for agriculture.

As early as 1956, it was estimated that 150 million cubic meters of waste-water would be recycled for agricultural usage. Within six years, fifty projects connecting Israeli farms to Municipal sewage treatment centers were up and running. By 1972, the number had climbed some 120, using 20% of all urban sewage. Today Israel recycles some 77% of its sewage, a rate far higher than other countries. For example, the U.S., for example, only recycled 2.4% of its municipal wastes The 340 million cubic meters of recycled sewage contribute roughly a fifth of Israel's total water supply. For irrigated agriculture, effluents constitute a far higher percentage of the available water sources and crop strategies increasingly take this into consideration.

By far, the country's largest treatment scheme is the Dan Region Wastewater Reclamation Project (Shafdan). Originally financed by a loan to the Israeli government from the World Bank during the 1970s, the plant today treats most of the sewage in the Tel Aviv metropolitan area at a high tertiary level. Some 130 MCM of near-drinking water quality are produced each year, most of it utilized by farmers in the Negev desert after it is injected into the coastal aquifer where it undergoes an additional filtration process.   There are several other large-scale wastewater treatment plants that provide agriculture with water of varying degrees, notably the Jerusalem, Haifa, Netanya and Beer Sheva facilities.

From the start of waste water reuse in Israel, there were questions raised about the quality of the recycled effluents. By 1953 the Ministry of Health recommended some of the first waste-water irrigation standards in the world, disqualifying raw sewage as an irrigation source and limiting the crops that could be grown with effluents to cotton, fodder and produce that is not consumed raw. Subsequent epidemiological studies did not reveal any statistically significant disparities in health indicators among farmers who worked with effluents and those who did not.

Recently, two major developments in wastewater reuse policy are contributing to a general upgrade in the field. These can be characterized as both "quantitative" and "qualitative" in nature.   First, in response to three years of consecutive droughts, in 2000 Israel's government decided to increase wastewater reuse to 500 MCM by 2010 (bringing the total percentage recycled to 74%). The attendant investment in sewage treatment and delivery infrastructure will expedite reductions in fresh water allocation to irrigation while preserving the scope of agriculture. It is expected that as a result of this investment, the amount of effluents available to farmers will increase to 450 MCM/ year, providing 50% of all water to agriculture.

Second, to minimize environmental health risk from the increase in wastewater reuse, in 2001 the Ministry of the Environment proposed to upgrade the water quality standards for both agricultural use of treated wastewater and its discharge into streams and rivers. The more stringent and expanded standard was approved by the government in 2005 and will be phased in through upgraded facilities.

Desalination At the instigation of Israel's first Prime Minister, David Ben Gurion by the 1960s, water managers were exploring the feasibility of large-scale desalination. Waters from the National Water Carrier did not reach the southern port city of Eilat and the neighboring Arava farming communities. Desalination proved to be the most feasible solution for local drinking water needs. Initially it was only brackish groundwater that was desalinized. With time, Eilat's "Sabha" facility was expanded and a sea water section was built that could treat 24,000 cubic meters a day for the cost of 90 cents a cubic meter.

Recently, Israel's government decided to build a series of five new desalination plants that are projected to produce over 500 MCM of desalinized water. The policy change reflects the substantial improvement in membrane technologies and the attendant drop in prices for desalinized water along with a growing recognition that traditional water resources are inadequate.. The first plant to open was in Ashkelon desalination plant. A privately financed: "BOT" water development, it produces some 120 million MCM of desalinized water per year at a cost of $\$0.52/m^3$. Figure 7 depicts the present trend in anticipated desalination facilities.

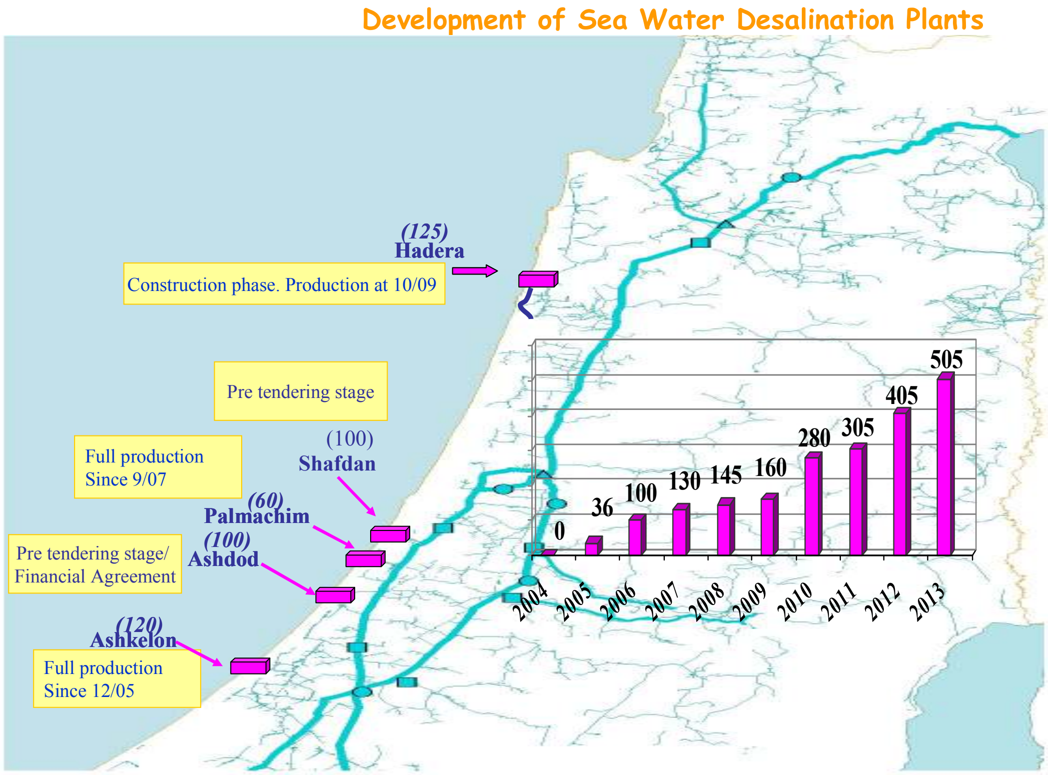

Figure 7: Israeli Desalination Plans

Source: Israel Water Authority, 2008

Conclusions: Towards Economic and Environmental Sustainability

For many years, Israeli efforts to reduce water demand focused on technology diffusion, in particular in the field of drip irrigation. Government pricing policies through the provision of artificially low-cost water,, especially to the agricultural sector, did little to encourage inefficiency. The ability to produce water coincided with general government policy trends which began to phase out the traditional subsidies for agricultural users. Indeed the country today is at the end of a major reform in water pricing. Table 2 shows present prices for water in Israel. Households in Israel pay according to a sliding scale where costs increase with the amounts utilized. While basic needs are supplied at relatively low costs, families that are water intensive, pay higher rates for their gardens and additional usage. The lower agricultural price tag reflects the actual reduced costs associated with supplying water to the farming sector which requires less treatment, quality control, etc.

Table 2: Water Pricing – Israel 2008

	Domestic	Agricultural	Wastewater	Public Institutions
1st Price	0.72 €	0.24 €	0.11 €	1.08 €
2nd Price	0.88 €	0.29 €		
3rd Price	1.41 €	0.38 €		

(*Source: Israel Water Authority, 2008)*

Beyond utilization of pricing, Israel for several years has encouraged conservation of water through regulation of municipalities (fines for leakages, day-time sprinkler use) standards for public toilets and technical assistance programs. There is a growing recognition that while water supply must continue to grow, conservation must be part of the solution as well.

From its inception, the story of Israel's water management has been unique internationally. As a developing country many of the country's hydrological achievements have been impressive. But there have been an environmental price paid for the aggressive expansion of water supply. Today, Israeli water resources face the twin challenge of negative trends in precipitation along with contamination of natural resources. To this can be added the challenge of learning to share management responsibilities and allocation of water with its neighbors. If the country's historic ideological zeal to develop water resources can be harnessed as part of an economically rational, technologically sophisticated policy orientation there is reason to believe that present challenges can be overcome.

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Water Resources: The Palestinians Perspective

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1. Palestinian water resources: quantities and use in the West Bank

Current status

This chapter consider the water resources available both in the West Bank and in the Gaza Strip. First review of the quantities is provided along with Palestinian claims and expectations for expanded resources. The chapter then considers the associated water qualities, the sources of contamination and challenges for environmental protection.

The existing Palestinian water resources in the West Bank are primarily derived from four aquifer basins (Table 1 and Figure 1) as well as a series of springs that emanate from the groundwater. Other sources of water are the Jordan River and wadi runoffs.

Table 1: Palestinian Aquifer Recharge rates

Aquifer Basin	Recharge Rates (Mcm/yr)
Eastern	100-172
Northeastern	130-200
Western	335-450
Gaza Coastal	55-65
Total	620-887

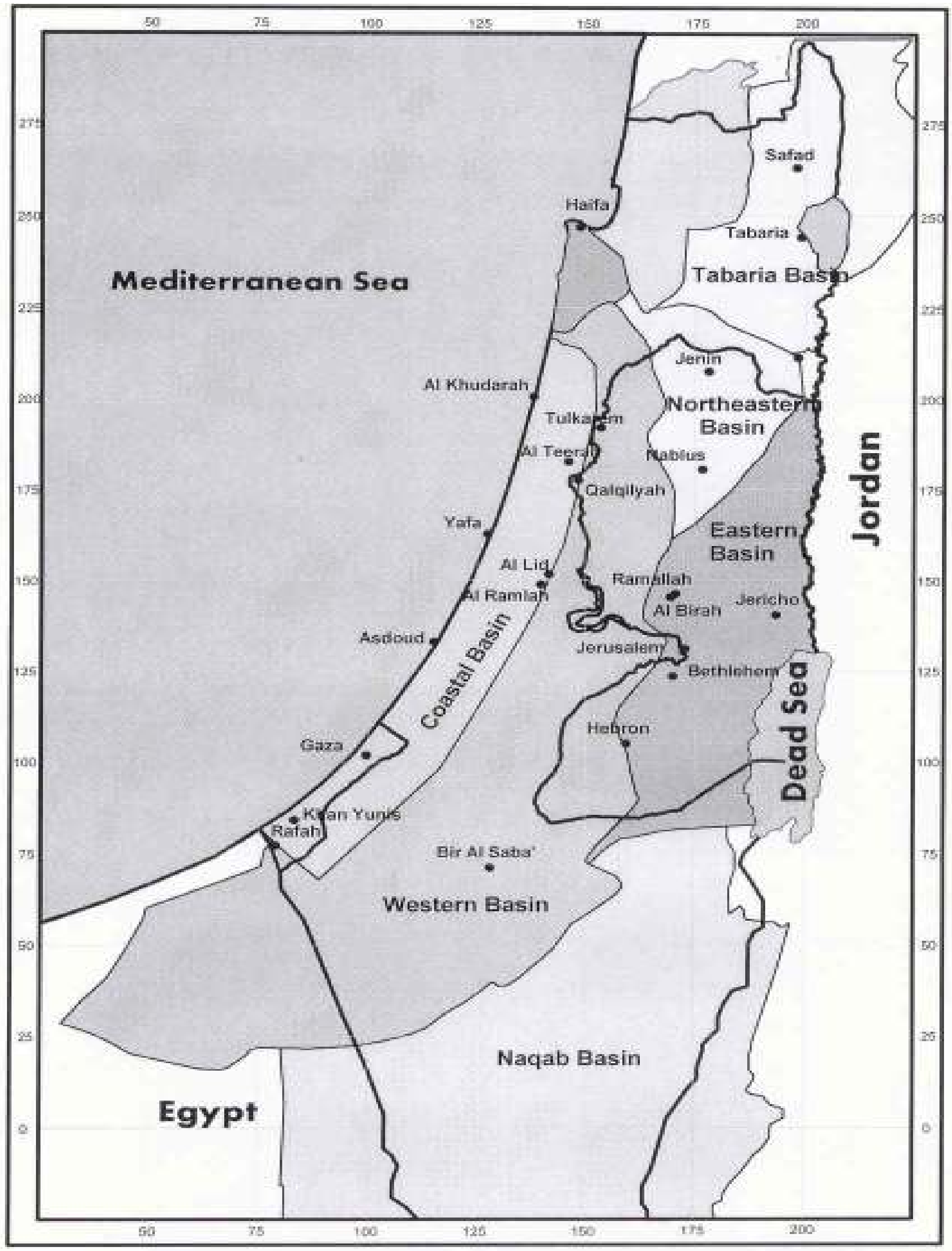


Figure 1: Location map showing Palestinian Aquifers
(Source *HWE Database*)

Tables 2, 3 and 4 represent the water use in Palestine for different purposes (Aliewi, 2005).

Table 2
Estimated Municipal and Industrial (Mcm/yr) total water use in Palestine

Region	Wells	Springs	Total
West Bank	55*	4	59
Gaza Strip	53**	-	53
Total	108	4	112

* 22 Mcm/yr are purchased from Israeli sources

** 48 Mcm/yr are abstracted from wells in the Gaza aquifer and 5 Mcm/yr are supplied from the Mekorot Israeli water company

Source: Data based on several recent studies conducted by Palestinian Water Authority (PWA) and the House of Water and Environment (HWE).

Table 3
Estimated Total Water Supply (Mcm/yr) for Irrigation in Palestine

Region	Wells	Brackish wells	Springs	Total
West Bank	40	0	49	89
Gaza Strip	43	42	0	85
Total	83	42	49	174

Source: Data based on recent several studies conducted by the PWA

Table 4
Estimated Total Water Supply (Mcm/yr) in Palestine

Region	Wells	Springs	Total
West Bank	95	53	148
Gaza Strip	138	0	138
Total	233	53	286

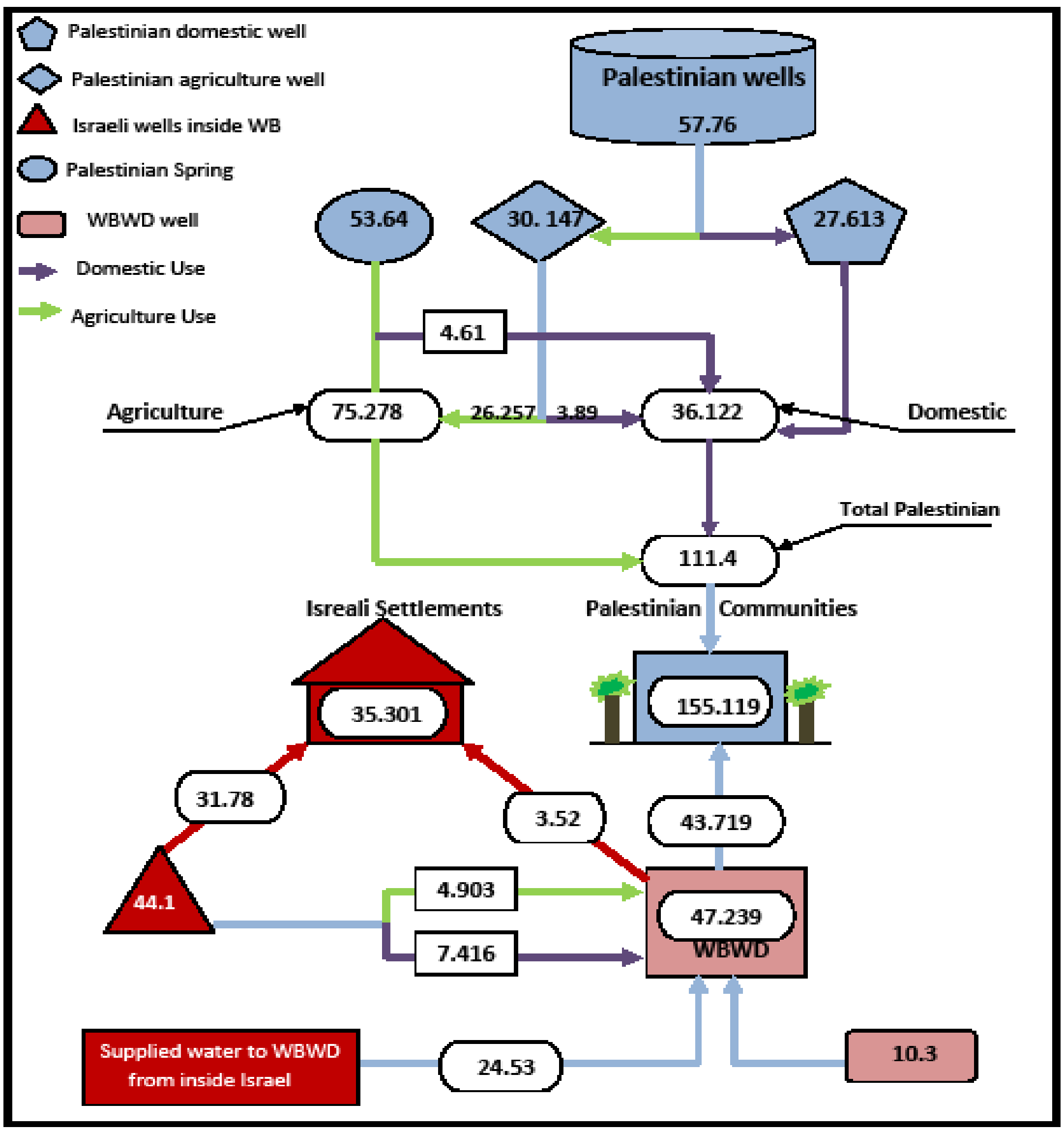
Source: Data based on several recent studies conducted by the PWA and HWE

The above tables show a generic picture which varies from year to year.

Figure 2 shows the complex picture of the water use and control in the West Bank for the year 2005. The Palestinians attribute these complicated dynamics to the following factors:

1. The presence of the Israeli settlements inside the West Bank. These settlements consume some 35 Mcm/yr from wells drilled in the West Bank and controlled by Israel plus a mixed source of water supplied to these settlements by the West Bank Water Department (WBWD). This mixed source is based largely on Palestinian wells that are operated by the WBWD. Relatively little water used by Israeli West Bank settlements is delivered from Israeli wells outside the 1967 West Bank borders.

2. While Palestinians consume their water from water resources under their control in the West Bank, they also purchase some 25 Mcm/yr of water per year from Israeli sources outside the West Bank as well as some 22 Mcm/yr from the WBWD



- All Quantities in Mcm/yr
- Water supply Quantities in West Bank fo rthe year 2005
- WB: West Bank
- WBWD: West Bank Water Department

Figure 2: The complex picture of the water use in the West Bank

3. The ownership of WBWD wells has yet to be settled in negotiations. Accordingly it is difficult to consider these wells to be fully within Palestinian sovereignty. According to the 1996 Oslo II agreement, the responsibilities and authorities over the West Bank Water Department (WBWD) should have been transferred to the Palestinian Water Authority, but this did not take place.

This complex system is not limited to sources of Palestinian water but is also true for the water supply system.

Water needs and gap

Municipal, industrial and agricultural water needs are presented in Tables 5 to 8. The gap between available water resources and needs is presented in Table 9 and Figure 3.

Table 5
Projected Municipal Water Needs in Mcm/yr*

Year	2000	2005	2010
West Bank	127	159	187
Gaza Strip	77	96	115
Total	204	255	302

* Assumption: 100-150 l/c/d, physical losses 8-12%.

Table 6
Projected Industrial Water Needs in Mcm/yr*

Year	2000	2005	2010
West Bank	5	25	30
Gaza Strip	3	16	18
Total	8	41	48

* Assumption: 8-16% of total municipal needs.

Table 7
Projected Agricultural Water Needs in Mcm/yr

Year	2000	2005	2010
West Bank	177	205	233
Gaza Strip	102	121	140
Total	279	326	373

Table 8
Estimated Total Water Needs (Mcm/yr) in Palestine

Region	Municipal			Industrial			Agricultural			Total		
	00	05	10	00	05	10	00	05	10	00	05	10
West Bank	127	159	187	5	25	30	177	205	233	309	389	450
Gaza Strip	77	96	115	3	16	18	102	121	140	182	233	273
Total	204	255	302	8	41	48	279	326	373	491	622	723

Table 9
Estimated Gap* (Mcm/yr) between Water Supply and needs in Palestine

Region	Supply			Needs			Gap		
	00	05	10	00	05	10	00	05	10
West Bank	148	148	148	309	389	450	161	241	302
Gaza Strip	138	138	138	182	233	273	44	95	135
Total	286	286	286	491	622	723	205	336	437

* The gap is estimated on the basis that the water supply of 2000 remains the same until 2010

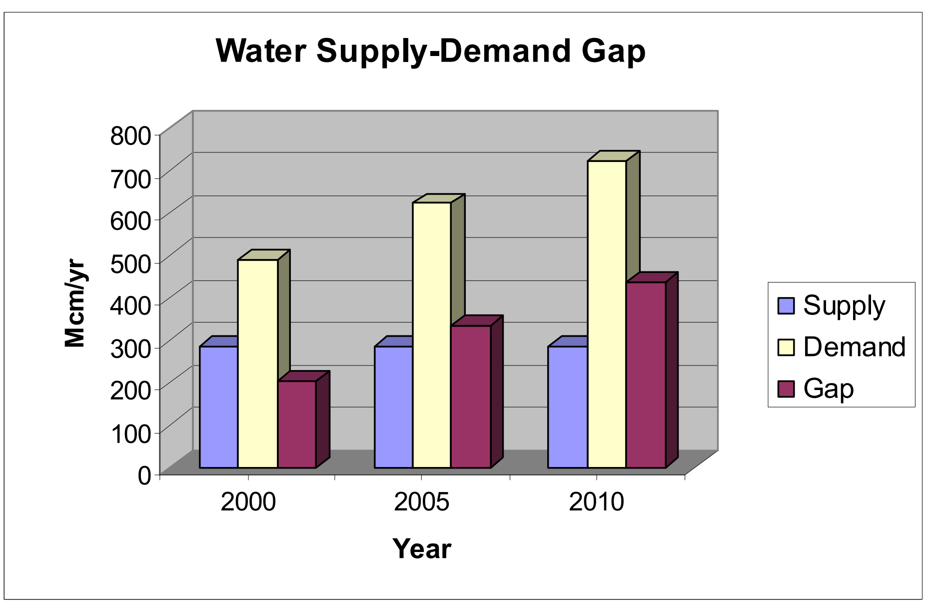


Figure 3: Water supply/needs gap in Palestine

Estimated present per capita current water use

The overall per capita supply rate (including losses) for urban domestic purposes in the West Bank was estimated to vary between 30 l/c/d and 70 l/c/d with an average of about 50 l/c/d. These estimated domestic water consumption rates are substantially lower than the WHO minimum value of 150 l/c/d due to the Israeli restrictions on water usage by the Palestinians. In the Gaza Strip, of the total water supplied to the domestic sector only some 8.9 Mcm/yr may be considered of acceptable qualityi (based on health considerations). This 8.9 Mcm/yr corresponds to only 18% of the water supplied by municipal wells and translates to a more acceptable per capita supply rate for domestic use of only about 13 l/c/d – less than the 150 l/c/d WHO recommended levels.

2. Water Quantities: Competing Claims

The average per capita consumption of 50 liter per day in the West Bank and the shortfall of some 350 Mcm/yr to the Palestinians in the West bank and Gaza places a constant pressure on the stability of the socio-economic future of the Palestinians. At present, the Palestinian citizens pay about $1.25 per 1m3 of water which is a high cost compared to the average income of the Palestinian citizen. At a minimum, Palestinians argue that Palestinian citizens should be entitled to receive a basic quantity of water (basic human right to water) amounting to at least 100 liter per day at an affordable cost. This water should be safe, acceptable and physically accessible.

The specific quantities that should be allocated to the Palestinians constitute a core political matter in the final status negotiations. But even so, a sustainable solution to the Palestinian water crisis will require effective management, development and planning of the resources. A consensus in this regard among Palestinians includes the following points:

- Palestinian water rights should be solved according to international legal principles which will guarantee sufficient quantities and grant sovereignty to Palestinians to utilize and control their water resources.

- Palestinian water rights should extend to their indigenous and shared ground water aquifers as well as surface water including the Jordan River.
- Final agreements will have to ensure removal of any obstacles in Palestinian lands that limit to Palestinian (e.g., access to wells currently controlled by Israel inside the West Bank, the separation wall constraints imposed by Israeli settlements, etc.).
- Bi-lateral and multi-lateral cooperation remain key elements in any final status negotiations over Palestinian water rights.

Beyond groundwater, the Jordan River and the surface runoff constitute the other sources of Palestinian water resources. Table 10 shows Palestinian claims for water rights that reach a total of 880 Mcm/yr. This means that this quantity needs to be available is order to meet future Palestinians water needs.

Table 10: Summary of Palestinian Water Rights

Source	Quantity Mcm/yr	Shared or indigenous	Possible Palestinian share*
1.Eastern Aquifer Basin	172	indigenous	172 (100%)
2. Northeastern Aquifer Basin	150	shared	90 (60%)
3. Western Aquifer Basin	443	shared	266 (60%)
4. Gaza Coastal Aquifer	65	indigenous in Gaza	65 (100%)
4. Jordan River including eastern Wadis	1500	shared	173 (11%)
5. Western Wadis	72	shared	72 (100%)
6.Dead Sea Wadis	17	shared	17 (100%)
7. Wadi Gaza	25	shared	25 (100%)
Total			880 Mcm/yr

*The figures here are based on assumptions and studies conducted by Palestinians (e.g. Mimi and Aliewi, 2006)
but the final figures will be decided and agreed upon in the final status negotiations.

3. Improving water resources and demand management

The growing gap between water supply and the needs of the Palestinian population makes the utilization of additional conventional and non-conventional water resources essential in the future. Moreover, it is important that Palestinian water policies be based on a sustainability assessment of water resources, taking into consideration socio-economic, governance and environmental issues. Palestinian water resources need to be managed in an integrated way that integrates laws, regulations, tariff structure, regulatory procedures, and a comprehensive wastewater strategy. This integrated water resources management should take into consideration structural and non-structural measures that should be adopted for the sustainable development of the water sector. It is important to adjust unsustainable consumption (e.g., agricultural use) of water and support the promotion of reforms in which water institutions are strengthened with integrated approaches and improved governance.

The following are important actions to reduce the gap between water supply and water needs in Palestine.

A. ***Demand management***

Rehabilitation of networks and reduction of physical losses: This includes internal household plumbing and use of water-saving and efficient fixtures; metering and tariffs; irrigation efficiency; restrictions on water demand for different purposes.

B. ***Wastewater re-use***

Having been collected wastewater should be treated to acceptable standards for re-use or for recharge of the aquifer. The challenge is to make use of this water for agriculture, while minimizing the health risk. All wastewater in the Gaza Strip should be made available for direct irrigation as needed or for recharge into the aquifer during the off-season. During the winter seasons the reclaimed water will need to be stored in the aquifer through infiltration basins and later reused by agriculture through recovery wells, particularly during the dry seasons.

C. ***Changes to water use policy***

No increase of freshwater supply to the agricultural sector should be considered beyond currents levels. Any water saving due to upgrading the agricultural water supply system, to modification of agricultural practices, techniques, or cropping patterns, will ultimately need to be reallocated to the domestic/industrial sector. Wells and springs in the West Bank need to be prioritized to meet domestic/ industrial water demand because the groundwater aquifer system offers the best level of water quality.

D. ***Groundwater supply development***

New water supplies should be introduced into the Palestinian water sector as soon as possible. The Palestinian water supply system can be increased from development in all Palestinian aquifer basins except the Gaza Coastal aquifer since this aquifer is already over pumped. This program should include rehabilitation of existing wells, springs development, converting Israel's Mekorot-operated wells located on Palestinian lands to the PWA, artificial recharge and exploitation of finite-thickness of fresh ground water lenses in Gaza. Finally, development of the Palestinian share in Jordan River should be an important component of supply.

E. ***Desalination***

The PWA is planning to have four large-scale seawater desalination plants in Gaza creating a total desalination capacity of about 45 Mcm/yr by 2010. Small-scale desalination plants, desalination of brackish groundwater and household treatment plants are also recommended for future plans.

F. ***Administrative and institutional management***

The sustainable development of the Palestinian water resources will require improving the institutional, administrative and legislative capabilities within the water sector.

G. ***Rain-water harvesting***

The farmers will participate in the process of reducing the gap between water supply and demand by using the harvested rainwater to feed their animals and partially irrigate their farms and gardens.

H. ***Environmental protection/conservation***

It is important to bring an end to the flow of raw municipal sewage as well as to other types of wastes (industrial waste, solid waste etc) discharge to the natural environment through implementation and collection and treatment works in Palestine.

4. Water quality in the West Bank

Protecting water quality is critical for ensuring the sustainable supply of water from West Bank groundwater resources. Water management strategies must provide solutions to the associated risks of pollution.

For many years, raw sewage from the Palestinian cities and localities and from Israeli settlements in the West Bank have been discharged into the wadis of the area.

Moreover, leachate from dumping sites, zebar from olive mills, industrial wastes, agricultural returns rich with agro-chemicals and hazardous wastes in addition to over-pumping of aquifers have caused groundwater quality of Palestinian aquifers to deteriorate. Since the carbonate aquifers of the West Bank have pronounced mature karst features, both above and below the water table, these aquifers show high potential for extensive and rapid spread of pollution.

A recent report considered the quality records available from some 490 wells and springs in the PWA database of the West Bank for major ion analyses (Ca, Mg, Na, K, HCO3, Cl, SO4 and NO3) (SUSMAQ (2003). The results suggest that there is ample cause for concern:

Chloride concentration values were found to range from 25 to 1000 mg/l. The highest levels of salinity (showing chloride concentration values of 600-2578 mg/l) were observed in 58 wells. These are found in the aquifers which extend as a narrow strip along the Jordan Valley, located close to the Jordan River in the Jericho District (Figure 4). Due to heavy pumping in the Jordan Valley a considerable decline in water table levels has also been observed with profound implications for salinity.

It was also noticed that much lower chloride concentrations exist in the areas near wadis as they are considered as sources of groundwater recharge in the West Bank Aquifers. The Palestinian standard for chloride in drinking water is set as a recommended maximum concentration of 250 mg/l, which is increased to 600 mg/l, when no alternative source is available. Chloride concentrations increase gradually from recharge areas in the eastern highland to the Jordan Valley in the east and from the south of the city of Nablus to El Jalemeh area in the north. The chloride concentration in groundwater located close to cities like Jerusalem, Bethlehem, Ramallah, Nablus and Jenin is far better, ranging from 50 and 100 mg/l (SUSMAQ, 2003).

The salination of groundwater is caused mainly by saline upconing in the Jordan Valley of the West Bank. The steep dipping of the aquifers along the Jordan Valley has caused deep circulation of the recharging groundwater, bringing it into contact with the contaminated salty formations that originate at greater depths. Recent drillings in the Jordan Valley show that salinity increases with depth. Salinity data obtained from one well in Jericho indicates that the chloride content increased from 380 mg/l at 30 meters depth to over 2000 mg/l at a depth of 162 meters. Increased salinity levels can also be a result of the flushing of soluble salts from the soil zone by excess irrigation water.

Nitrate concentration in groundwater is naturally low but can reach high levels as a result of agricultural runoff, runoff from garbage dumps, or contamination from human or animal wastes. The toxicity of nitrate to humans is mainly attributable to its reduction to nitrite; as well known, with young infants being the most susceptible population. The PWA has adopted the World Health Organization's upper limit is of 50 mg/l as (NO3) with 70 mg/l deemed acceptable to PWA in the absence of any better quality water source. The nitrate standards are designed to prevent health risks from methemoglobinemia (blue baby syndrome), which in acute cases can cause premature death and disability. Nitrate concentrations in West Bank water sources have at time reached problematic concentrations (e.g.> 50 mg/l) especially in newly urbanized areas. High levels have been measured in Qalqilia, Tulkarem, Jenin and Nablus in the north, Ramallah and Jericho in the center, and the Beit Jala-Hebron region in the south. However, these hotspots appear to be comparatively localized and water in the vicinity is generally of better quality (SUSMAQ, 2003).

Total Dissolved Solids (TDS) can have an important effect on the taste of drinking-water. The palatability of water with TDS level of less than 600 mg/l is generally considered to be good; drinking-water becomes increasingly unpalatable at TDS levels greater than 1200 mg/l. The presence of high levels of TDS may also be objectionable to consumers owing to excessive scaling in water pipes, heaters, boilers, and household appliances. The PWA acceptable limit is 1000 mg/l, while up to 1500 mg/l is acceptable in the absence of any better source. Problem levels tend to be encountered only towards the boundaries of the West Bank, in other words down-dip within each of the West Bank aquifer basins. This suggests that while urbanization plays a part in the creation of high TDS concentrations, down-dip water-rock interaction must also be a contributory cause (SUSMAQ, 2003).

Sulphate is not a serious problem anywhere in the West Bank. All water resources except for one are below the 'taste' level of 250 mg/l. Yet, trends suggest that there may be reason for concern, as some sites where SO_4 concentrations are now higher than in the past. These findings might simply be anomalous analytical artifacts but they may well be the result of changes in pumping regimes (for example where groundwater is strongly layered in terms of quality) or simply the flushing over time of pockets of poor-quality water in gypsiferous strata. Figure 4 shows maps for chloride, nitrate, sulphate and TDS values across the West Bank respectively.

In the northern part of the West bank, recent deep drilling of wells penetrating very thick layers of Senonian chalk reveals processes of ion exchange between bituminous shale and limestone, serving to increase the concentration of fluoride and decrease the levels of calcium and magnesium. The high level of fluoride constitutes a major health risk.

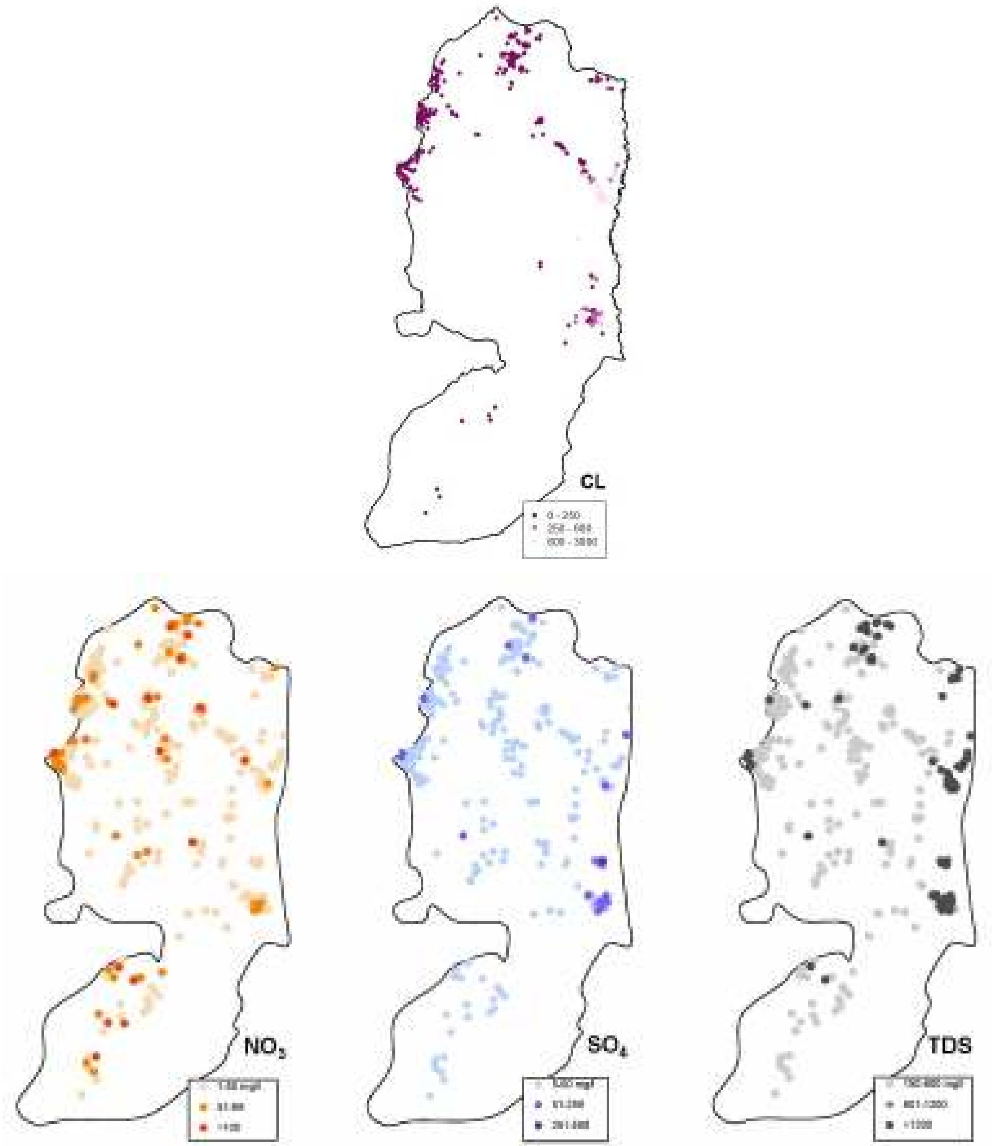


Figure 4. Distribution of groundwater chloride, nitrate, sulphate and TDS across the West Bank. Source: SUSMAQ (2003)

5. Water Quality in the Gaza Coastal Aquifer

Groundwater in Gaza segment of the coastal aquifer is generally of poor quality, characterized by medium to high salinity levels. Very few parts of this aquifer still have high water quality. These few reasonable segments of the aquifer that are located along the extreme north and extreme south of the Strip (Figure 5). In the whole of the coastal region, aquifer quality remains a critical issue as the values of nitrates and chlorides are frequently extremely high.

Chloride (salinity) affects usability for irrigation and water supply. Intensive exploitation of groundwater in the Gaza Strip during the past 30-40 years has disturbed the natural equilibrium between fresh and saline waters, and has resulted in increased salinity in most areas. In Gaza City, chloride values in several wells are increasing at rates up to 10 mg/l per year. Sources of chloride that can be documented or inferred within the Gaza Strip are seawater intrusion, lateral inflow of brackish water from Israel in the middle and southern areas of the Gaza Strip (chloride concentration varying from 800 to 2000 mg/l) as well as the presence of deep brines at the base of the coastal aquifer with chloride concentrations of 40,000 to 60,000 mg/l. Figure 5 shows the distribution of chloride levels in Gaza Strip in the year 2004.

Nitrate concentrations are also increasing rapidly in the urban centers with concentrations rising as much as 10 mg/l per year (PWA, 2000). The main sources of nitrates are fertilizers and domestic sewage effluent. The quantities of sewage that infiltrate through cesspits and septic tanks to the water table on an annual basis are significant, and are estimated to be about 12 Mcm/yr. In contrast to salinity, groundwater flowing from the east has relatively low nitrate levels. This reflected in the maps shown in Figure 5. Nitrate concentration of hundreds of mg/l is common, however, in the groundwater of the Strip (PWA, 2000). Nitrate levels, in particular those found in the water used for drinking purposes in certain parts of the region are well above WHO standards. In some extreme cases this can lead to premature death and disability.

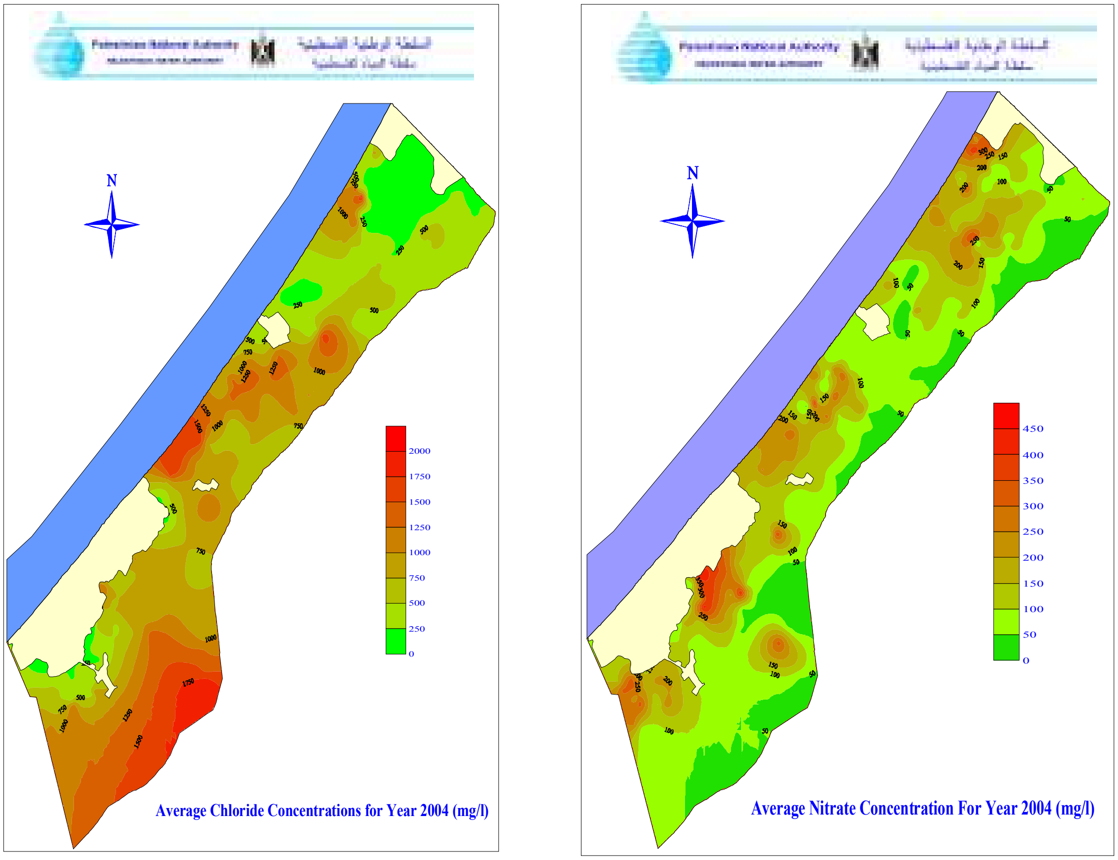


Figure 5. Average groundwater salinity (Cl - mg/l) and nitrate concentration (NO3 – mg/l) for year 2004 of the Coastal Aquifer in the Gaza Strip (Al-Banna et al, 2006).

6. Conclusions

The average per capita consumption of 50 liter per day in the West Bank and the 13 liter per day per capita (suitable for drinking purposes) in Gaza put a constant pressure on the stability of any socio-economic future of the Palestinians. Without a sufficient and safe supply of water it will be difficult to ensure a stable future for the emerging Palestinian State. The existence of additional water sources will make n Palestinians perceive the quantities of water allocated to the new state as a core political issue in the final status negotiations. Such issues must be resolved before moving on to the problem of sustainable management, development and planning. Palestinian water rights should be resolved according to international law principles which will guarantee sufficient quantities and grant sovereignty to Palestinians to utilize and control their water resources.

The growing gap between the water supply and the needs of Palestinian communities makes additional conventional and non-conventional water resources essential. Moreover, putting in place water policies based on a sustainability assessment of the water resource taking into consideration socio-economic, governance and environmental issues will be an important stage in the move toward sustainability.

In the West Bank, the sources of pollution continue to cause severe damage to the mature karst aquifers. The poor sanitation services, poor management of sewage and solid waste, the over application of fertilizers and pesticides in the agricultural sector as well as the over-extraction and reduction in storage volumes have produced substantial pollution levels in the Palestinian aquifers. During all the years of occupation, the Israeli civil administration never built a wastewater treatment plant in the West Bank, although Israeli settlements contributed to the pollution of the West Bank aquifers. Contamination of water will minimize the already limited quantities of water resources in Palestine, i.e., enlarging the gap between water supply and needs. Hence, there is a critical challenge to sustainable development of the Palestinian water resources. Wastewater treatment is an essential element in alleviating pollution to the Palestinian water resources. This matter needs to be addressed as part of a holistic approach that takes into consideration, institutionalization of wastewater treatment and reuse for agriculture, regulations and laws, wastewater treatment technologies and strategies e

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Editors' Summary of Workshop Discussion

There appears to be little substantive differences between Israeli and Palestinian assessments of available water resources and their condition. For the most part, the sides are no longer arguing about facts or data, but rather allocation and policy. There are of course clear objective disparities in the hydrological circumstances of the two populations which inform each party's positions.

The average per capita consumption of 50 liter per day in the West Bank and the 13 liter per day per capita (suitable for drinking purposes) in Gaza place constant pressure on the stability and socio-economic conditions of a future Palestinian state. Without a sufficient and safe supply of water, Palestinians believe that it will be difficult to ensure a sustainable future. Especially during a period of consecutive drought years, Israel and particularly its agricultural sector also have legitimate concerns about hydrological sustainability. Israel's economy and political interests are, however, far less vulnerable to present and projected levels of water scarcity. Moreover, its negotiators have never denied the importance *for Israel* of ensuring that a Palestinian state not be a thirsty one, or a country with an advanced sanitary infrastructure. Hence, reaching a future agreement in the water realm need not involve the traditional "zero-sum-game" approaches that characterized past negotiations.

The Palestinians perceive the quantities of water allocated to them as a core political issue in the final status negotiations. Because of past sensitivities and the historic dynamics of occupation, they prefer to view the issue in terms of "rights". Indeed, Palestinian have always held that their water rights should extend to their "indigenous and shared ground water aquifers" as well as to surface waters that run through their jurisdiction, in particular the Jordan River. It should, however, be emphasized that never have the Palestinians demanded "equal" quantities of water – but rather only what they believe to be their fair share. While Palestinians would like water quantity issues resolved before moving on to the problem of sustainable management, development and planning to protect water quality, it is likely that they will agree that the two topics be considered in tandem.

Israel has always seen the resolution of conflict over water as part of a broader package of peace issues. Given the new affordability of desalinated water and the relatively modest role of agriculture in Israel's economy, it is likely to be one of the core issues about which it will be easier for Israel to be flexible. At the same time, Israel realizes that coordinated efforts to protect water resources are critical for a long term strategy. Just as the provisions regulating water were among the most detailed and ambitious of the interim agreements between the two parties, a future agreement from Israel's perspective should go far beyond allocations accounting and include management, policy, standards and enforcement.

Palestinians insist that water rights be resolved according to principles of international law which they believe will guarantee them sufficient quantities and the sovereignty to utilize and control their water resources. The basic axiom of international water law though is rather vague, requiring only that all sides receive *a reasonable and equitable share.* This should not be deemed problematic as the principle is sufficiently amorphous and given to sufficiently flexible interpretations to allow Israel to agree to have it as a basis for resolving the existing disputes. To be sure, the two sides do not agree about the legality of past water developing for Israeli settlements, nor to the legitimacy of Israel's "historic rights" to water resources that originate in the West Bank. Yet, resolving these differences ultimately belong to the "tit for tat" bickering of the past. They should not stand in the way of a pragmatic approach that can reach accommodation about water distribution, management and common efforts to improve water quality.

There are some differences in the data that the two sides will bring to the table, particularly in the area of potential aquifer recharge and present and future needs. It is possible that climate change and dwindling precipitation are at the heart of the gap in perceptions. Such disparities can be clarified and resolved either through joint scientific commissions or the utilization of third party arbiters. Ultimately, these differences are not excessive, and any remaining disagreements will probably be no greater than water production in a single large desalination plant.

While in the past, Palestinians preferred to focus on water rights rather than expanding available sources, the steady rise in population over the past decade appears to have changed this position. Indeed, talking about water "needs" appears to be a more constructive way to get past disagreements which sabotaged progress in the past. Both sides agree that the growing gap between supply and needs of Palestinian communities makes additional conventional and non-conventional water resources essential. Moreover, putting in place water policies based on a sustainability assessment of the water resource taking into consideration socio-economic, governance and environmental issues, are considered to be an important stage in the move toward sustainability.

There is also broad acknowledgement of the significance of significant upgrades in waste treatment and environmental infrastructure. This is not a concession on the part of Palestinians but a clearer recognition of the consequences of continued neglect in this field. Poor sanitation services, poor management of sewage and solid waste and over application of fertilizers and pesticides in the agricultural sector and over-extraction and reduction in storage volumes have caused pollution to the Palestinian aquifers and harm their quality life fare more acutely than Israel's. Contamination of water will also minimize the already limited quantities of water resources in Palestine, exacerbating Palestinian shortages, even after future Israeli concessions.

While Palestinians correctly point out that occupying Israeli forces never built a wastewater treatment plant in the West Bank during all years of occupation, they also realize that relieving themselves of the "historic blame" will do little to improve their quality of life. The peace process brings with it rare opportunities to receive considerable funds to "jump start" a Palestinian waste treatment system that is based on tertiary treatment that can supply high quality to Palestinian agriculture. There is a growing recognition that most Palestinian farmers will be hard pressed to receive any water as Palestinian population continues to grow and quality of life improve.

In short, the present quantity and quality of the water resources on both sides are well understood. It is clear that regardless of the ultimate allocation, present supply is insufficient for the population that will be living in the region in the near future. The steady contamination of these resources exacerbates the situation significantly. Yet, there are reasons for optimism including:

- The feasibility of expanded water production via desalination;
- Greater Palestinian commitment to expanded water supply from waste water reuse (and desalination);
- The increasing commitment on both sides to environmental protection;
- The proven interest of donor nations in establishing water infrastructure.

All these point to water as a source of future cooperation rather than conflict.

2. Past Water Agreements and their Implementation

As the focus of this book is the potential for reaching a comprehensive final agreement for allocation and management of water resources, it is important to consider relevant past accords between the parties, their achievements and failures. These two chapters provide a review of the provisions in the interim peace agreement with regards to water, for the first time considering their actual implementation. Not surprisingly, Palestinian and Israeli perceptions are dissimilar.

The Oslo II Accords in Retrospect: Implementation of the Water Provisions in the Israeli and Palestinian Interim Peace Agreements

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1. Background

Article 40 of the Oslo II agreement between the Israelis and Palestinians forms the normative basis for cooperation in the water and sewage sector during the interim period as identified in the agreement for the West Bank and Gaza Strip. In this chapter we will highlight the main issues addressed through a brief review of the expectations of the Palestinian side versus what it perceives as has actually happened on the ground.

The main principles that cover Article 40 can be summarized in the following:

1. Israel recognizes the Palestinian water rights in the West Bank;
2. Both sides recognize the necessity of developing additional water for various uses;
3. Both sides agree to coordinate the management of water and sewage resources and systems;
4. Additional quantities of water need to be made available to Palestinians during the interim period for different uses; and
5. The need to establish a permanent Joint Water Committee (JWC) for the interim period.

2. The Palestinian Expectations

In general, the expectations from the outcomes of the Oslo II agreement in September 1995 directly after the signing of the agreement were very high. In the fields of drinking water and wastewater, like other sectors, it was assumed that the sides would fully implement the agreement within the proposed time frame of the interim period. The main outcomes that Palestinians expected from Article 40 can be summarized through review of the following five issues:

Additional water quantities

As agreed under Article 40, Palestinians were to receive additional quantity of 28.6 Mcm/year for domestic purposes as immediate needs according to a program detailing where, how and whose responsibility it was to develop these additional quantities. This 28.6 MCM was considered to be part of the 70 to 80 Mcm/year that forms the Palestinian future water needs for the different sectors. It is worth mentioning that according to the agreement, the above mentioned quantities were not in any way to prejudice the provision of additional water in the ultimate negotiations that would determine final Palestinian water rights in the West Bank.

Upgrading of water networks

The Palestinian water and wastewater infrastructure in the West Bank and Gaza Strip in 1995 was fragmented, insufficient and deteriorating. More than 68% of the Palestinian communities in the West Bank did not have a water supply network. Only nine municipalities had wastewater collection system and these were hardly comprehensive. Two or three inadequate wastewater treatment plants existed. The Palestinians hoped that with the signing of this agreement and the help of the donor community, during the interim period they would be able to construct, upgrade and rehabilitate most of their water and wastewater systems.

Data and information

Data availability is an important element in any water resources management and planning effort. All the data related to water during the occupation period were in the hand of the Israeli authorities. It was expected that this data would be provided after the signing of the agreement. According to Article 40, both sides are to cooperate in the exchange of available relevant water and sewage data. According to Article 40 the data regarding hydrological resources was to include:

1) Measurements and maps related to water resources and uses;
2) Reports, plans, studies, researches and project documents related to water and Sewage; and
3) Data concerning the existing extractions, utilization and estimated potential of the Eastern, North-Eastern and Western Aquifer systems.

The Joint Water Committee (JWC)

The establishment of the Joint Water Committee (JWC) was seen as one of the positive outcomes of Article 40. The main function of the JWC is to address all water and sewage related issues in the West Bank and Gaza Strip, including generating additional data and facilitating an information exchange. Its primary mandate was to include:

a. Coordinating management of water resources;
b. Coordinating management of water and sewage systems;
c. Protection of water resources and water and sewage systems;
e. Oversight of the operation of the joint supervision and enforcement mechanism;
f. Resolution of water and sewage related disputes;
g. Cooperation in the field of water and sewage, as detailed in Article 40;
h. Establishing arrangements for supplying water between the two sides; and
i. Setting up monitoring systems.

Cooperation

Article 40, as mentioned encourages cooperation in the water and sewage sector. The expectations for such cooperation were high from the Palestinian perspective. In light of the agreement, Palestinians expected cooperation with the Israelis in the following fields:

a. Cooperation concerning regional development programs;

b. Cooperation, within the framework of the joint Israeli-Palestinian -American Committee, on water production and development related projects agreed upon by the JWC;

c. Cooperation in the promotion and development of other agreed water-related and sewage-related joint projects, in existing or future multilateral forums;

d. Cooperation in expediting water-related technology transfer, research and development, training, and setting of standards; and

e. Cooperation in the development of mechanisms for dealing with water-related and sewage related natural and man-made emergencies and extreme conditions.

3. Status of Implementation

In general, the status of the implementation of Article 40 has not met Palestinian expectations. Reviewing the same five major issues mentioned above, the following section tries to summarize implementation and what has actually happened and implemented regarding the agreed-upon actions mandated by Article 40.

Additional water quantities

According to article 40, the total agreed-upon quantity of water supplied to the Palestinians was to range between70 to 80 million cubic meters of water per year (Mcm/year). Of this, 28.6 Mcm/year were to be provided to meet the immediate needs of domestic use. The following is a summary of the actual results:

1. Instead of the 28.6 Mcm/year for domestic use, an amount of 29.4 Mcm/year was approved by the Joint Water Committee (JWC). The actual quantity of water supplied from the approved amount, however has only been 19.7 Mcm/year. This

is because the 5 Mcm/year approved to Gaza Strip has not yet been implemented and the 24.4 Mcm/year approved for pumping in the West Bank had an actual yield of 19.7 Mcm/year. Here it should be mentioned that the Israeli commitment of 4.5 Mcm/year of the 28.6 Mcm/year has been met while the Israeli commitment of 5 Mcm/year to Gaza Strip has not been fulfilled.

2. The remainder quantity of 40.6 to 50.6 Mcm/year over the 29.4 was not implemented. This quantity can be divided into two components:
    a. 19.1 Mcm/year was to come from seventeen wells approved by the JWC: Three drilled wells of 4.1 Mcm/year in Hebron and Bethlehem area and 15 Mcm/year from the remaining fourteen wells. Of these, three wells, of 5 Mcm/year have reached the stage of tenders and the remaining 11 wells of 10 mcm/year are being developed or in need of funding.
    b. 21.5 to 31.5 Mcm/year from wells were submitted for approval to JWC.

The above numbers show that the quantities of water agreed upon according to Article 40 have not been implemented. The shortfall can be attributed to lack of funding or delayed approval by the Israeli representatives at the JWC.

Water and Sewerage Networks

During the past fifteen years and since the signing of the Oslo Agreement, different water and sewerage projects have been implemented. According to Article 40, any water or sewerage projects must receive approval from the JWC. During the last twelve years, the the Palestinian side submitted 384 projects to the JWC. Two-hundred and thirty two projects were approved while 53 were not. Approval for some 99 projects is still pending.

This suggests that roughly 65% of the submitted projects were approved. Yet of the 232 approved projects, only 138 projects were actually implemented while 79 projects were not (25 projects are partially implemented and 11projects are different stages of completion). Ultimately, this means that only 40% of the submitted projects were actually implemented.

The situation regarding the progress of sewerage projects is even worse. Sixteen sewerage projects were submitted to the JWC for approval. Only eight of the submitted projects were approved and eight were not approved. Out of the eight approved projects only one project is implemented and two projects are under implementation.

To conclude it can be said that due to the steady efforts of the Palestinian Water Authority, the water sector has improved in many areas of the West Bank especially in areas where new water supply systems were installed. In the Gaza Strip, the lack the additional supply of 5 Mcm/year by the Israelis to Gaza Strip and the poor condition of the Gaza groundwater aquifer made it impossible to see improvements as meaningful as those found in the West Bank.

Data and information

The lack of data remains one of the biggest problems facing the Palestinian Water Authority. That is why the data and information provisions in Article 40 were of great importance to the newly established Palestinian Water Authority (PWA) at the time of signing of the agreement. Since the signing of the agreement, official data and information transfer can be described as minimal and fragmented despite the efforts of the other involved parties in the peace process. Little serious effort was made to expedite data transfer and sharing of information from the official Israeli side. This has been especially true for data characterizing the North Eastern and Western aquifers and the Jordan River.

At the same time a much better data and information sharing process has emergeed at the unofficial level through bi-lateral and multi-lateral research activities. Reports, plans, studies, research and project documents flowed in both directions between Israeli and Palestinian researchers. A variety of joint efforts took place to collect data for research purposes. These efforts were supported by the donor community such as USAID, EU and many individual European countries.

In conclusion, data and information sharing, especially on the official level, have not met Palestinian expectations. At the same time, joint data sharing and joint research on the non-official level have been good and can offer a good model for other sectors of common interest.

The Joint Water Committee (JWC)

The JWC was established after the signing of the Oslo Agreement. The function of the JWC is to serve as the main coordinating player for the two sides in the sphere of water and sewerage. The JWC's role ranges from coordination, management and exchange of information to overseeing and monitoring. This role was directly affected by the ongoing political conditions that have prevailed since the signing of the agreement. This can be seen from the number of meetings of the joint technical sub-committee.

The technical committee has convened a total of 52 meetings during the past ten years. For the first four years, the committee met at almost a constant rate of 5 meetings every year.) In the years 2000 to 2001, the committee was doing much better with about 10 meetings per year. From the Palestinian perspective, this momentum is due to the fact that the Labor party was in power in Israel during that period of time. After the year 2001, the Committee met only twice a year which appears to be a function of the political conditions on the ground and the orientation of the Likud-led and subsequently the Kadima-led governments.

From the above, one can see that the JWC was not able to fulfill its role according to Article 40. On the other hand, the JWC is doing far better than many of the other joint committees established under the Oslo Agreement.

Cooperation

Cooperation in the sectors of water and sewerage has not been uniform across the many sectors that were to work together pursuant to the Oslo Peace accords. The level of cooperation dramatically varies between official bodies and non-government entities. On the official level, communication continues to exist between the Israelis and Palestinians officials but it cannot be described as meaningful cooperation.

An example of the need for improved cooperation is the *Jenin Project*. Internal networks, reservoirs, and pumping station were constructed for eleven villages in the Jenin district that have a total population of 45,000. According to Article 40, Jenin's water was to come from a well to be drilled in 1996 in the Jenin area. The Israeli representative rejected the requests for drilling of this well, however, and proposed selling water to these villages from Israel through the Israeli water company Mekorot instead. The Palestinians were very reluctant to accept this offer but in the end the Palestinians accepted it. The Israelis then changed their mind again so that the well was not drilled until 1999.

At the same time, fruitful cooperation has existed between different Israeli and Palestinian non-governmental bodies especially in the area of research. Different research projects were implemented, both on the bi-lateral level and on the multi-lateral level. The problem with these cooperative efforts is their tendency to be fragmented and uncoordinated.

To conclude, there is a need to improve cooperation, especially between the official water bodies on both sides. Areas of priority include issues concerning regional development programs, promotion and development of water-related and sewage-related joint projects, water-related technology transfer, research and development, training, and setting of standards.

4. Obstacles

Political instability is considered to be the major obstacle in implementing the provisions of Article 40. In addition to political instability, full implementation of Article 40 faces many other obstacles and practices. Those are:

1. Delays in discussing the projects for approvals within the technical sub-committees
2. Delays in convening JWC meetings;

3. Delays in issuance of approvals from JWC and signing the protocols of the meeting;
4. Delays in issuance of permits especially in area C of the West Bank;
5. Donor funding commitments which are ultimately dependent on issuing approval and permits;
6. The limited number of qualified drilling companies (mainly drilling of wells);
7. The long duration of implementation from start to finish especially for certain types of projects, such as drilling of wells;
8. Delays in land acquisition procedures; and
9. Unavailability of funds to implement approved projects.

Some of the above-mentioned constraints and obstacles could be easily lifted with goodwill. Others are more difficult to be lifted, such as funding which requires third party involvement, in particular from the donor community.

5. Lessons learned

Based on the above dynamics, the following are the major lessons learned from the Palestinian experience in implementing Article 40 in general and in participating in the JWC in particular:

1. Goodwill and a genuine spirit of equality should prevail in implementation. Neither side should veto the water projects of the other side without just cause and risk to critical national interests.
2. Cooperation between the two parties remains essential. When it existed, it enabled coordinated management and provision of effective services in the water sector.
3. Implementation needs to be timely enough to meet the basic water needs of the Palestinians.
4. Unilateral implementation of projects should be avoided.
5. Implementation needs to cover all areas, including area C, where there is the greatest need for water. Cooperation should include water resources, supply, and infrastructure.

6. Lengthy procedures should be avoided.

7. Data should be exchanged regarding all relevant elements, especially water abstractions.

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Article 40: an Israeli Retrospective

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1. Introduction:

In 1995, an *interim* agreement between Israel and the Palestinians was signed in Washington. As implied by its title, it was supposed to be an *interim* agreement that would pave the path towards the Permanent Status Settlement. The Permanent Status Settlement in fact was to have been signed by 2000. Sadly, twelve years later, there is no sign of a permanent agreement. An unfortunate chain of events and harsh political climate diverted the implementation of this agreement from its original goals. However, regardless of its background the agreement still stands.

The following chapter will present Israeli perceptions regarding the implementation of one of the important chapters of the interim agreement: "Article 40: Water and Sewage." The first section will briefly present the most significant principles of article 40 according to Israeli perceptions along with initial expectations regarding their implementation. The second section will present the status of implementation of these principles. First, the main problems associated with the implementation will be presented followed by important achievements. The last section will present lessons and recommendations based on the experience of implementing the interim agreement. This chapter is based on interviews with Israeli key actors in the design and implementation of the Interim agreement.

2. The Israeli Perception of the Main Principles of Article 4

Interviewees indicated a number of principles as the most important elements in article 40. In this section the importance of these principles and the expectations regarding their implementation will be briefly presented from the Israeli point of view. The principles are categorized according to the main themes they refer to and not according to the specific clauses of the agreement.

Developing Additional Water Resources

Israeli interviewees unanimously indicated the obligation of both sides to develop additional water sources (Principle 2)[1] as one of the most important principles of the agreement. Both Israelis and the Palestinians are aware that natural water resources will not be able to provide all water necessities of both sides regardless of their distribution, in light of the water scarcity in the region. Therefore, there is no escape from developing new water sources. In this regard Israelis expected that the Palestinians would support the development of additional water sources, especially desalination solutions as well as restoration of brackish water.

Balance Management of Quantity and Quality of Water Resources

Facing chronic water shortages in the Mediterranean, preserving the integrity of existing water sources should be a paramount priority. This principle is anchored in some of the clauses of the agreement that are all considered as fundamental and important principles of the agreement. Generally, Israelis expected the Palestinians to cooperate in preserving both the quality and the quantity of existing water sources.

Water Pollution Prevention

Untreated sewage is considered by Israeli water resources experts to be one of the most considerable threats to the natural water resources in the area that are mainly ground water aquifers. Sewage treatment is considered a challenge even in the most developed countries and recently, complaints regarding the US sewage treatment were filed in the US Congress. The Israeli sewage system is far from perfect, although it has significantly improved during the previous years. At the time the agreement was signed, Israeli experts sense that awareness about the severity of the sewage situation and the need for upgrading treatment in Israel was in its infancy while in the Palestinian areas, it was practically non-existent. Irreversible damage to ground water aquifer has already started due to sewage contamination. Both sides acknowledged the need to prevent water

[1] 'Both sides recognize the necessity to develop additional water for various uses' (Principe 2).

pollution in sections 21, 23.[2] Therefore, one of the main expectations of the Israelis was to establish Palestinian sewage treatment infrastructure and even expedite the use of treated effluents as an additional water source for irrigation.

Protecting Water Systems

Both sides recognize that water systems and water supplies are necessary for the survival of the civilian community. Therefore, both sides are obligated not to harm water systems even in armed actions.[3]

Water Allocation to the Palestinian

In Israelis views, one of the most important elements of the agreement was to clearly allocate water to the Palestinian population to avoid water shortage and thirst. Section 6 of the agreement specifies the immediate needs of the Palestinians which are 28.6 mcm/year. Section 7 specifies their future needs as 70-80 mcm/year. The specific allocation requirements are important for achieving order and clarity.

3. Cooperation Mechanism

Coordinated Management of Water and Sewage

The basic principles of water management in the agreement involve "coordinated" management of water and sewage. Coordinated management (as opposed to joint management) means that each party is in charge of water supplies and treatment for its population. Each water source is assigned a manager who is in charge of water allocation to the other party. The northern and western aquifers are managed by Israelis and the Eastern aquifer is managed by Palestinians. The basic understanding is that the management of water resources should follow an overall view that would take into account the natural qualities of the resource. The understanding that any harm caused by either of the sides affects all parties calls for cooperative actions under some conditions.

[2] "21. Each side shall take all necessary measures to prevent any harm, pollution, or deterioration of water quality of the water resources".
"23.Each side shall take all necessary measures to prevent any pollution or contamination of the water and sewage systems, including those of the other side."

[3] "22. Each side shall take all necessary measures for the physical protection of water and sewage systems in their respective areas."

Some frameworks for cooperation were set within the agreement to establish the *de facto* required cooperation.

Joint Water Committee (JWC)

The JWC is the main mechanism for cooperation. In this committee all the joint water and sewage issues are discussed. In practice, under the JWC, additional specific committees for cooperation were established as well: The Joint Technical Committee that was established for dealing with technical aspects of problems and for providing the professional and technical background to the discussions of the JWC. The technical committee was comprised of five sub-committees in: ground water supply, sewage treatment, drilling committee (where in terms of the aquifer there should be drilling) and price committee (for establishing water prices). In addition ad-hoc committees were established in light of a specific need. The JWC was perceived as a flexible mechanism that would provide solutions to the changing needs and realities.

Joint Supervision and Enforcement Mechanism

The JSETS, a series of teams whose Palestinian and Israeli members were to work jointly on enforcement, were considered by Israelis to be one of the most important mechanisms in the agreement. The JSETS were supposed to monitor the implementation of the agreement, and especially to eliminate unauthorized water uses and drilling. The JSETS are important both in eliminating illegal activities and in establishing cooperation between the parties. The required level of cooperation within the JSEST units is particularly high as they have to operate in full cooperation.

In sum, Israelis expressed high expectations from the agreement. In particular it was hoped that the agreement would produce cooperation in the field of developing additional water resources, preserving the existing resources, allocating water to the Palestinians and establishing institutional cooperation in both technical areas and enforcement.

4. Implementation Status

The following sections evaluate the implementation of the main principles of article 40 as viewed by Israeli representatives. Main problems are categorized as problematic, with inadequate implementation of the main principles indicated above casting a shadow over the entire implementation of article 40. And yet, the agreement has not been entirely a failure. On the contrary, this section concludes with the main achievements in water and sewage management due to the implementation of article 40.

Developing Additional Water Resources

One of the main disappointments in the implementation of the agreement from the Israeli side was the lack of developing additional water resources. Two main reasons were raised by the Israeli interviewees to explain the reluctance of Palestinians to develop additional water resources. The first reason is connected to the differences in the interests and expectations of the sides regarding water issues and establishing the grounds for the Permanent Status Agreement. The Palestinians approached the negotiations towards the interim agreement with a strong interest that their water rights be acknowledged by Israel. The Israelis, on the other hand adopted the pragmatic approach that seeks solutions on the basis of needs. Israelis also did not want to harm their existing water uses.

In the interim agreement, in fact a compromise was reached: in the first principle of Article 40 "Israel recognizes the Palestinian water rights in the West Bank". However, the specific rights are to be negotiated the permanent status negotiations and settled in the Permanent Status Agreement. Therefore, the differences in the interests and approaches of both sides still exist. In the implementation of the agreement, regardless of principle 2 that recognizes the necessity to develop additional water, Palestinians still hold their position that Israel should provide them with all the natural water resources at the first stage (including water from the Jordan River and the Kinneret lake) and only then will they be willing to consider developing additional water resources.

The interviewees indicated that another claim that stands in the way of cooperation in the development of additional water resources involves the different economic conditions of the two sides. The Palestinians claim that the Israelis are rich enough to solve their own needs with desalination so they can provide the Palestinians with the natural water and use desalination to solve whatever water shortages they may have.

Israelis believe that reluctance by Palestinians to develop additional water resources is also connected to their perceptions about the connection between land and water. They perceive the water rights as a part of their proof of sovereignty over the land.

Nonetheless, despite the general reluctance of Palestinians to develop additional water resources, at certain stages they seemed more open to the idea and there is heterogeneity in the opinions of different individual Palestinians. For instance, the Palestinian Negotiation Support Unit (NSU) adopted an interim approach according to which Israel should transfer some of its water rights to the Palestinians and in parallel additional water resources will be adopted.

The following sections briefly present the current status of projects for developing additional water resources:

- Water allocation to the Gaza strip – the Interim Agreement states that Israel is to supply Gaza with water that may come from desalination.[4] The Mekorot company in fact, did build the required pipelines that should transfer five cubic meters of water from Ashkelon to Gaza in accordance with the interim agreement. The Americans started building the continuation of pipelines but have not finished the construction due to the rise of the Hamas government. The Norwegians decided to finish the setting of pipelines and to pay the desalination price of one year. Currently American consent is still pending.

- Buying desalinated water from Ashkelon – Past Israeli Water Commissioner Shimon Tal offered Nabil Sharif, (who was the Palestinian water commissioner at the time) to sign a contract with the Ashkelon desalination plant to provide Gaza with desalinated water with American funding. The Palestinian politicians would

[4] "7)a) "Israeli commitment" 6) "Additional supply to the Gaza Strip - 5 mcm/year" b)(3) "A new pipeline to convey the 5 mcm/year from the existing Israeli water system to the Gaza Strip. In the future, this quantity will come from desalination in Israel."

not hear of it. One of their main reasons for their declining this initiative was their desire to establish water rights over allocations from the Jordan river and the Kinneret lake.

- Desalination facility in Hadera – the Israelis offered to build a desalination facility in Hadera for the Palestinians, funded by the donor countries. Israel and the donor countries planned the route of the pipeline. The capacity of this facility should have been 50 cubic meters for the use of the Northern West Bank. However, despite the approval of the professional staff of the Palestinian Authority, the Palestinian Politicians refused to approve the project and currently implementation is nowhere in sight.

- Brakish Water – the Palestinians acknowledge that using brackish water for irrigation is a necessary part of any future plan. However, they are afraid that the water may be too expensive due to the associated sewage treatment system and the necessary winter impounding. Israelis recognize that Palestinians irrigate in the area of Jerusalem with brackish water but perceive the quantities utilized as negligible.

- Red-Dead Canal – the Palestinians are designated to be a beneficiary in the planned project of transferring water from the Red Sea into the Dead Sea. Israelis agree that if implemented, the Palestinians should also enjoy one of the outcomes of this project -- that is desalinated water. Accordingly, recent Palestinian agreement to receive desalinated water from the project, is seen as revealing a softening in their resistance to relying on desalinated water.

Balance Management of Quantity and Quality of Water Resources

Under the principle of ‘balanced management of water resources’ Israeli interviewees generally expressed their satisfaction about the protection of water resources, as will be elaborated in the following sections. Nevertheless, they articulated significant disappointment about Palestinian efforts to preserve the quality of water through upgrading insufficient sewage treatment as well as their efforts to preserve water quantity by preventing water losses (water consumption that are unaccounted for that may mainly be caused by leakage from pipelines and water thefts). These two phenomena will be described later.

Water Pollution Prevention (Sewage Treatment)

One of the main claims of the Israeli side towards the Palestinians involves the insufficient sewage treatment by the Palestinians. All interviewees indicated sewage problem as one of the gravest disappointments in the implementation of Article 40.

The following assumptions were raised as possible explanations for the lack of progress in sewage treatment during the first years of implementing article 40:

- Blaming the Israelis for not treating the sewage in the Palestinian territories during the occupation. While these allegations may have some justification, the Israelis had hoped that article 40 would have opened a new era.
- Palestinians hoped that the donations would eventually be transferred to other issues that they consider as more pressing.
- The observable harm was mostly in the Israeli territories as sewage flows downstream in the Wadi.

Since the inception of article 40, 250 million dollars (U.S.) have been allocated to sewage treatment in the Palestinian Authority. And yet, sewage still flows into Israeli Wadis. Lately, however, there are signs of modest improvement due to some actions that were taken.

- One of the reasons for stalling treatment plans was due to bureaucracy in the procedure of authorizing sewage treatment plans. Until 2002, the procedures were mostly the following: Palestinians submitted partial and unsatisfactory (in Israelis views) sewage treatment plans. Israelis recommended modifications and the discussions would invariably be delayed for another half a year each time. In 2003 both sides signed a Memorandum of Understanding for promotion of sewage treatment plans. The MOU indicated that each side was in charge of treating its own sewage and that the treatment facilities would be established in two stages. The first stage was to provide a "20/30" level of treatment for COD and suspended solids respective. During the second stage, treatment levels were to be upgraded to reach the discharge levels recommended by the Inbar Committee – which set future sewage treatment standards for waste water reuse.

- Both sides realized that they should develop a "united front" if they wanted to generation international financial aid. As soon as they approached the donors with a joint agenda, they started receiving financial aid for sewage treatment projects.

- Donors reformed their donation system so that it would be targeted to support specific infrastructure projects. Money allocated to support sewage treatment facilities could not be used for other purposes any longer.

- The Palestinian population did not accept the 'solution' of discharging raw sewage into the sea.

- The Israeli government reimbursed itself with 90 million shekels due to damages that were caused by lack of sewage treatment by the Palestinians.

The aforementioned changes are perceived by the Israelis as having led to some improvements but there are still some major obstacles to proper sewage treatment:

- Political Problems - There is a "disconnect" between the professional staff of the Water and Sewage Authority in the Palestinian Authority and municipal officials. The professional staff that is in charge of water and sewage within the Palestinian Authority understands the importance of sewage treatment. However decision makers and politicians in the municipalities do not appear to care or understand these issues. The professional staff is unable to provide any solutions without the support from the political level.

- Palestinian Priorities – the Palestinian authority places water supply as a top priority whereas sewage treatment is a much lower priority. In accordance with this prioritization, the Water Authority is in charge of sewage treatment and not the environmental authority.

- Capacity Problems – maintenance and operation is one of the major challenges of sewage treatment even in highly developed countries. Therefore, construction of sewage treatment facilities does not solve the problem of sewage treatment in and of itself when the relevant authority does not have maintenance capacity. Most sewage treatment facilities that are currently built by donors, are funded for an additional three years of maintenance and operation, above and beyond the construction of physical plants. For the long-term, maintenance of sewage treatment facilities bears costs. In Israel, residents are required to pay for their water consumption. These costs are supposed to include costs of sewage treatment. In the Palestinian Authority, Israelis sense that residents do not pay for the full costs of water consumption (presumably because they do not have the income to pay for it).

- General external problems – in addition to the three aforementioned specific problems, sewage treatment is stalled due to the general external problems that are discussed in section 2.2.

Current status of sewage treatment facilities:

Israeli experts take a dim view of the present conditions prevailing in Palestinian sewage infrastructure:

- The only facility that is properly functioning is the Ramalla treatment facility.
- The following facilities are in different stages of construction or their construction ceased from some reason.

- Hebron – the construction of the sewage treatment facility that was funded by the US was stopped due to the overall policy regarding financial assistance to a Hamas-led government.
- Northern Gaza strip – a ~40M$ facility is under construction, funded by the World Bank.
- Center of the Gaza strip 80M$ sewage facility treatment project is ready for a tender.
- Tul Karem-Nablus, Genin and Ramalla – this year large projects are planned to start.

Water Losses

Unauthorized drilling and water theft by the Palestinian farmers is perceived as one of the three main problems associated with implementing Article 40 identified by Israelis. The most common water method of water theft is simply drilling a hole in a water pipe. The impression of some of the interviewees was that although it seems that this activity is privately initiated by Palestinian farmers, Palestinian authorities are either incapable or reluctant to put an end to this phenomenon.

The most significant incidents of water thefts identified by Israelis have been:

- When Israel evacuated the Gaza strip, wells pipes and equipment were left for the use of the Palestinians but instead of using them, pipes and equipment were stolen and 2000 unauthorized wells were drilled that practically ruined the aquifer.
- In the West Bank unauthorized drilling problem is less severe as deep drills are required in order to reach the water and they are less accessible. Only deep drills may severely harm the aquifer. Deep drilling requires special machinery that can easily be located by the JSETS. In addition, the Palestinians have learned from the experience with the Gaza Strip and have taken measures to stop the theft. But still water theft is a widespread phenomenon as Palestinians hook into pipe lines, stealing from Palestinians and Israeli settlements alike.

Water depression resulting from losses within the pipeline system reaches extreme percentage in the Palestinian authority. According to the Palestinian Water Authority reports it reaches 36% of water losses. The Israeli government offered to assist the Palestinian Authorities in implementing the Israeli system of prevention of water losses and reduction in domestic water consumption, but Palestinians refused to take advantage of this system.

5. Problems in Cooperation

Information Transfer

Israeli authorities hold that the Israel Water and Sewage Authority for some time have provided Palestinians with information regarding drills, quantities and water levels. However, information transfer is deemed as potentially problematic when the information might be used against the Israeli water interests, especially in a Permanent Status Settlement. Much of the transferred information is passed through unofficial channels or in the different joint committees.

Water Management

Israelis would have liked to witness a stronger, more organized and economic Palestinian water system management with citizens paying for their water consumption and their part in sewage treatment. Israelis would like to see the water and sewage system treated as a holistic system where effluents are treated, at least some of them utilized. The Israelis offered the Palestinians to benefit from their experience. For instance, the Palestinians were invited to learn water management practices from the Mekorot Water Company. Although several individual Palestinians took some classes and tours they have not yet implemented their knowledge, perhaps due to internal difficulties. Another initiative that has not been realized was the joint center for desalination that as to train technicians and workers in desalination facilities. Despite a mutual agreement, international support and the German assistance this project has never been implemented.

6. External Problems Affecting the Implementation

The Lack of a Permanent Agreement

Twelve years have passed since the initiation of the Interim Agreement even as its life expectancy was only supposed to be five years, at which time the Permanent Agreement would have been signed. The anticipation of an ultimate Permanent Agreement stymies development in several areas, such as development of water resources. Until the Permanent Agreement is signed, both sides try to avoid actions that may weaken their position regarding negotiations over a Permanent Agreement. One of the still open questions involves the determination of the final jurisdictional borders. As water rights are immediately connected to land ownership, disputes acknowledging the Palestinians rights to certain aquifers may be viewed as acknowledging their land ownership in these areas. Similarly, the Palestinians sewage treatment responsibility is also related to the sovereignty over these areas. Joint infrastructure projects, while possibly efficient in the short-run may be perceived by Palestinians as implicitly granting sovereignty and are avoided due to political considerations. For instance, joint sewage programs with Israeli settlements were declined by the Palestinians as it may be considered as acknowledging the Israeli settlements.

Security

Israelis also see a link between lack of progress and the security situation. The current unstable security situation in the area - with bombing and assassinations still occurring on a regular basis - serve to drive away donor nations who prefer to invest money in more stable and promising initiatives. In addition, when money is available, contractors are often prevented from reaching the relevant areas, equipment is stalled and projects end up with excessive cost.

Budget

Sewage systems and water supply systems cost money. Israelis believe that at present Palestinians do not have the required amount for solving all the existing problems. However, some of the interviewees think that solutions were available that might have overcome budgetary problem. For instance, approaching donors with a commonly agreed upon agenda, tends to generate interest and investment. A holistic approach to water and sewage (such as using brakish water for irrigation) could also save money and improve water allocation and might also be popular with donors.

Political Problems

Two main political problems have made a difficult situation even worse. The first is the rise of the Hamas government followed by the boycott of the Palestinian Authority by the Israeli and U.S. governments. As a result, much of the activities that are defined in the interim agreement have been suspended, many donations to the Palestinians were denied and projects have been stalled.

Another internal political problem that Israelis see as existing since the initiation of the Interim Agreement is the friction between the water professionals and central government officials and the local governments. After the rise of the Hamas, the problem became aggravated as local authorities are often from the Fatach and the government is from the Hamas. The two levels do not communicate and budget allocations are not transferred.

6. **Significant Achievements**

General Evaluation

All interviewees agreed that despite the mutual complaints the agreement and its implementation have been relatively good and the agreement has fulfilled its intended purpose. It is telling that no Israeli expert interviewed wants to breach the agreement or cancel it. All sides want to preserve its main principles ('a stable agreement is the best indication of a successful agreement'). In addition ensuring of water supply during the summer was mentioned as an indication to the successful work of the Joint water committee. Despite the potential gravity of water problems during the summer season and exacerbated scarcity, there has not been a single summer when the Palestinian Authority faced a humanitarian water crisis.

The most encouraging outcome of the agreement, from the Israeli perspective, therefore, is the enhanced cooperation between the sides. Before the agreement there was no cooperation whatsoever. Naturally, the Joint Water Committees did not exist. The agreement facilitates cooperation and sets the groundwork for its implementation.

Cooperation

JWC **-** Interviewees agreed that the JWC was an important and good mechanism. Via the JWC, sides reached many understandings and projects were approved. This was the only committee that was spawned by the Interim Agreement that continued to operate, despite the Intifada, continuous political problems and the Hamas victory in the Palestinian Authority elections. When political or security problems prevented physical meetings, creative solutions were adopted, such as telephone discussions and meetings in neutral places to sign the necessary protocols.

The main achievement of the JWC has been its ability to work together – raising problems and finding solutions. For instance, before every summer, a joint meeting is held where the Palestinians raise problems. Israel assisted the Palestinians in the maintenance of drillings, found creative solutions, bringing water in tankers etc. Prior to the last official meeting of the JWC all the issues that were raised by the committee were taken care of. A new list has been created, but the Hamas government was elected and since than things ground to a halt.

One possible explanation for the successful operation of the committee is mutual need. The Palestinians could not drill any additional wells without the authorization of the JWC and the Israelis were duty bound to coordinate regarding their settlements. Therefore, both sides needed one another in order to conduct any kind of activity in the West Bank. In addition, the JWC was largely composed of professional staff and not politicians. The decision by the Israeli government, to allow the committee to keep working was unique to the water field. In practice, the JWC has been a vehicle for updating and keeping the agreement alive after it should have been replaced by the permanent agreement.

JSETs

Officially, five teams worked jointly till 2000. After an unfortunate incident, in which a Palestinian officer shot an Israeli officer in the joint policing force, the teams were decomposed. For the next two years no control unit operated. In 2002 new enforcement teams of the Israeli Water Commission started operating. There is some cooperation with the Palestinians who have teams of their own. At present, the teams no longer operate together, according to the instructions in the Interim Agreement. But they do cooperate in particular in the area of information transfer. Israelis believe that the Palestinian teams feel threatened by Palestinian civilians, which compromise their actions.

However, claims have been made that even while operating quite rapidly, the cooperation between the teams has been less than successful. The Palestinians were not motivated to cooperate in the joint teams since all the enforcement resources were targeted at the Palestinians. At the same time the Palestinian JSET members were considered to be 'rats' by their own people if they reported offences. Israelis were under the impression that their complaints were not taken care of.

P*reserving Water Systems*

Generally, the overall objective of the Agreement – to preserve the water systems from physical harm - is considered to have been quite successful. From the Israeli side, the military is deemed as having done its best not to harm water systems, though occasionally during violent episodes, water systems were harmed. The Palestinian side also tried not to deliberately harm water systems, nor to poison wells or bomb them. Even terrorist activities have not targeted water systems.

Basing on the interim agreement, subsequent agreements were signed by the Israeli water commission and the Palestinian Director of the Water Authority for preventing harm to water resources. Also, the water commissionaires issued joint statements to the Arabic press with a call for the Palestinian population not to harm the water systems as both sides rely on the same natural systems.

Water Allocation

One of the prominent achievements of the Interim Agreement was the significant rise in water supply to Palestinians homes. In 1967, at the start of the Israeli occupation of the West Bank, only 10% of the Palestinian households were connected to the water supply system. Today 90% of the Palestinian households are connected to the water system.

While signing the agreement the Palestinians were supplied with 120 million cubic meters of additional water yearly. In fact, following the Interim Agreement water supply exceeded even the quantities Israel undertook to provide. Currently the quantity provided by Israel is almost double the quantity that was promised in the agreement – Israel provides 50 cubic meters extra, beyond its obligations under the agreement, a matter that is confirmed by Palestinian records. Two main reasons caused the decision to increase the water supply beyond the amount stipulated in the agreement. The first was the fact that the Interim Agreement was in force longer than anticipated so that the hydrological situation had to reflect demographic and other changes. The second explanation involves miscalculation from the Israeli side, in part because no one was in charge of joining the provided quantities.

Lessons and Recommendations

The implementation of Article 40 and the cooperation that was achieved through the JWC surmounted many political and other obstacles. The experience under the Interim Agreement involving water governance proves that when good will exists, true cooperation is possible. Although water related issues are unique in many ways general lessons are possible as well. Arguably, one of the most important tools of Article 40 was the JWC. The updating mechanism that was implemented by the JWC left the agreement alive long after it was supposed to have perished.

However, the true cooperation was also the result of the unique relationships that were built between human beings that spent a significant amount of time with each other in the negotiations towards the agreement and during its implementation. It is enough to hear the Israeli appreciation about the professional staff in the Palestinian Authority to understand that personal relationships play a significant role in the realization of different goals. This observation may constitute a double-edged sword, as personal staff may change, affecting the conciliatory nature of the cooperation.

In addition, in cases where both sides were mutually dependent to act the agreement worked smoothly. In several instances the cooperation proved worth while as both sides achieved more donations when their requests were uniform and coordinated. However, when both sides face great deficiencies (such as the case of sewage treatment facilities) significant problems arose.

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Editors' Summary

Objectively there are areas of clear progress that can be identified with the execution of Article 40 of the interim peace accord with its provisions for cooperation in water management. And yet there are also clearly disappointments on both sides. Palestinians have a difficult time translating "objective" indicators of progress associated with implementation with a general reality of deterioration with which they are familiar day-to-day. For example, while Palestinians today objectively have access to greater quantities of water than they did prior to the agreement, the effect on the pervasive scarcity is hardly recognizable. The 60 liter/day allocation to average Palestinian families is only half that of Jordan's, where water scarcity is considered a major problem. With a population that is still growing exponentially, along with a water delivery infrastructure that still suffers from chronic leakages, substantial numbers of Palestinians rely on cisterns and rain collection to meet their basic needs. Article 40 did little to change that.

Israeli disappointment involves the broader breakdown of the peace process. From its perspective far more money went into Palestinian military hardware than into water infrastructure. Moreover, while copious quantities of international support were available following the interim agreement, Palestinians did not prioritize water resource development and sewage infrastructure.

The most obvious inadequacy of the Article 40 is the interim agreements is that while the provisions were attended to be an ephemeral stop on a much broader route that was to redefine the hydrological reality of the region, after almost fifteen years the agreement functions as a permanent accord for which it is poorly equipped. Hence, a clear definition of Palestinian water rights remains unresolved. Palestinians had little reason to anticipate Israeli good will in this area when there was constant enmity between the parties. Water was clearly one of the areas that Israel will want to use a bargaining chip in the overall jockeying towards a final peace treaty. Therefore, it has not shown alacrity about making "concessions" up front.

One of the failures of Article 40 involves the lack of meaningful progress in the establishment of upgrading Palestinian sewage systems. Despite considerable investment by donor nations in the Palestinian economy, only some 6-7% of sewage is fully treated. Political instability offers much of the explanation for the lack of progress. Yet, all the same, the agreement has not served to help garner the necessary resources to transform the sewage profile and establish the hygienic infrastructure necessary for a modern, healthy land. Palestinians are miffed that Israel has unilaterally deducted funds from development funds for the Palestinians in order to cover the expenses of sewage treatment plants and to remunerate their expenses associated with transboundary discharge of pollution.

While the "stamina" of the Joint Water Committee and its ability to maintain operations during the most tumultuous of times is often held up as one of the greatest achievements of Article 40, the institution itself is the target of considerable criticism. Outside commentators have pointed to an inherent flaw of the JWC involving is the absence of symmetry between the sides. The interim agreement requires Palestinians to run all water-related projects through the JWC. But no parallel expectations are made of Israel in its ventures in the water management field. This lack of symmetry is considered unfair, giving the JWC a reputation as an exploitive body that perpetuates Israeli domination.

The JWC is also an excellent example of the gap in perceptions between the two sides. Because of the requirement for consensus in making its decisions, Palestinians for the most part see the committee as a continuation of Israeli domination which serves to stymie independent hydrological initiatives and perpetuate Israeli control over their water resources. They are argue that important sewage projects were delayed because one Israeli representative had reservations.

Clearly, Article 40 has produced important progress. Palestinian water rights were recognized and the quantities that they received expanded dramatically. The sides showed a willingness to create a joint enforcement program, which although not yet operational could easily be activated as the framework has already been agreed upon. Notwithstanding Palestinian frustration with the JWC, it has proven to be a forum where problems can be addressed and on occasion solved together. But it is important that efforts begin to move forward towards a final agreement, which can offer a more equitable and sustainable arrangement.

The Water Culture of Israelis and Palestinians

This chapter offers insights into the culture of water for Israelis and Palestinians. For a final agreement to be sustainable, it is important that it enjoy broad popular support. Hence, it is important to explore how Israelis and Palestinians think about water and its relationship to the larger issues of Israeli-Palestinian relations. The chapter also offers an opportunity to present how a shared water culture might emerge from the present conflict, rather than two separate cultures aspiring to attain sustainable management of common water resources.

WATER CULTURE IN ISRAEL

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With at least 60% of water going to agriculture in Israel, its unique role in local Israeli culture and heritage must be understood and the practical manifestations integrated into an assessment of water culture in Israel. Agriculture has historically enjoyed a privileged place among Israeli decision-makers. Explanations for this were somewhat self-evident during the 1950s and 1960s when agriculture provided some 30% of the country's GNP and most of the top political leadership had either immediate or historical connections with agricultural communities.

Zionism, the nationalistic ideology of the Jewish people, always elevated agricultural pursuits, encouraging "pioneer" immigrants to establish new settlements. A variety of philosophers, most notably A.D. Gordon, espoused a Tolstoyic perception that only through work connected to the land and soil could personal redemption be achieved. Among agriculture's additional merits that were traditionally cited are: its contribution to "food security," as a means of self-sufficiency, its role in stymieing land claims by Arabs, establishing territorial claims in the periphery of the country and in the past, socialising new immigrants and reducing unemployment.

This ideological and cultural bias provides some explanation for present water policies, which today are frequently inconsistent with economic and environmental considerations. To begin with, the economic contribution of agriculture to Israel's economic profile has fallen to 3% of GNP and 2% of overall employment. Crop subsidies nevertheless remain high for certain crops. Large-scale water diversions for agriculture have also left a hydrological legacy of dry streams and depleted aquifers. Chief among these is the National Water Carrier that diverts water from the Sea of Galilee in the northern part of the Jordan river watershed to the south of the country for irrigation. The project changed the way Israelis perceived their water resources and made almost the entire country dependent on a single water supply system. This large scale diversion scheme plays an important role in reducing the flow of water in the lower Jordan and hence the amount of water that can reach the Dead Sea. The building of the canal was also a source of friction with Syria in the build up to the war of 1967.

Part of the reason for Israel's societal commitment to water infrastructure can be attributed to the political elites who continue to dominate governmental decision-makers. Senior politicians and government officials are disproportionately affiliated with the agricultural sector, affecting their decisions about water allocation, pricing and distribution. The political patronage of Israel's top leadership to agricultural interests continues and they remain protected in recent years regardless of party affiliation. For example, past Prime Minister Ehud Barak, a "leftist" politician, was raised on an agricultural kibbutz, while recent Prime Minister Ariel Sharon, head of a "right-wing" party makes his home on a ranch in the Negev. Recently, a plan by the Israel Treasury to raise water prices by 70% for the agricultural sector was tabled after intervention from the Minister of Agriculture.

While the general public is increasingly urban in its domicile (over 90% of the population in Israel live in moderate to large cities) Zionist's veneration of ruralist living remains a critical factor in the water culture of the national psyche. This is true from an ideological perspective, with farming still considered among the more admirable (albeit barely profitable) professions. Youth movements, a critical socialisation factor for large segments of upper-middle class Israeli youth, still spend considerable time in summer work camps in agricultural communities.

Agriculture also holds a place in the national aesthetic psyche. A study by Fleisher et. al. (2001) from the Hebrew University in Jerusalem based on a "willingness to pay" survey suggests that the value for passive use (among tourists) for agricultural production in Israel's Jezreel valley and Israel's Huleh valley exceed the actual production amounts. This is not inconsistent with similar preferences in England, which has protected its bucolic countryside with legislation to subsidise rural landscapes. Quite simply, Israelis like farms, and farmers have convinced decision-makers (and to a certain extent the public at large) that the resulting prodigious water consumption is justified.

Hence, it can be argued that there are dominating "ideological and cultural" factors that explain the country's ongoing commitment to agriculture and that by association, water is just too valuable to flow freely in the country's rivers and streams. By this logic, the price now being paid by the Dead Sea's alarming decline is due to the veneration of water for agriculture among all other needs. Within this context however, the agricultural sector has increasingly come to understand that fresh water is a scarce resource that will be largely replaced by treated wastewater and desalination. At the same time, the growing of certain crops may become prohibitively expensive or impossible due to the salinity levels in effluents and available brackish waters. The transition to drip irrigation for many crops from the 1970s onward has allowed many Israelis farmers to maintain productivity even as actual allocations were cut periodically.

Reductions in allocations of water to agriculture were primarily enacted in the face of droughts but also reflected a growing domestic demand for water. The adaptability of Israel's agricultural sectors and the relatively consistent fluctuations in allocations over the past decade confirm that while agriculture's general support is fairly unquestioned, the actual quantity of water consumed is open to change and influence of additional factors. In fact, recent data show that water consumption in agriculture is declining (Table 1).

Table 1: Potable water consumption by purpose in percentages

(Source: Israel Central Bureau of Statistics, 2004)

	1983	**1993**	**2003**
Agriculture	71	64	56
Domestic	23	29	38
Industry	6	7	6
Total	100	100	100

Not only the actual magnitude, but also the form of the agricultural community's water portfolio can be considered a dynamic factor. Past experience suggests that it is a nimble sector that has frequently changed its crop profiles in order to exploit market opportunities or to respond to the agronomic constraints posed by different water qualities. This same flexibility can be seen in its utilisation of wastewater, which as already mentioned provides it with a growing percentage of its hydrologic needs (Table 2). Cultural resistance to wastewater, that has been an obstacle to its utilisation in certain Arab societies, constitutes less of a barrier among Israeli communities. The use of wastewater for domestic purposes, however, has been shown to be unpopular. The amount of fresh water (potable) being consumed by agriculture is declining somewhat, although the savings of fresh water in agriculture are being rapidly consumed by the growing domestic sector.

Table 2: Water production in agriculture by type in percentages

(Source: Israel Central Bureau of Statistics, 2004)

	1993	**2003**

Potable	71	56
Effluent	12	24
Brackish	6	11
Surface	11	9
Total	100	100

From an empirical perspective, the primary factors that can be associated with any reduction in agricultural productivity, and hence water, involve land conversion. For many years, the powerful stature of agriculture in Israeli political culture was bolstered by the Planning and Building Law (1965) that gave agricultural zoning preference as a "default" to any land that was not designated otherwise. During the 1990s, a series of decisions changed that and led to a softening of zoning lines, which had previously locked farmers into agricultural usage. At the same time, economic conditions and high inflationary loans pushed many farmers to take advantage of the new "speculative" opportunities and sell out. This transformation can be seen in such regions as the Sharon and Galilee. It also changed the perception of farmers among environmentalists, who increasingly valued agriculture as a hedge against urban sprawl.

Israel's national water management system since its inception has been designed to subsidise agricultural production. Water prices constitute one of the clearest economic manifestations of the aforementioned ideological commitment to agriculture. Under Israel's Water Law (1959) farmers pay a low-base price for the first 50% of their water allotment. The price increases for the next 30% and 20% respectively. Water prices for water with high concentrations of salinity or effluents can be as much as 100% cheaper. This provides a disincentive to water conservation, as low-grade saline water is cheap to use. Urban uses can be charged as much as eight times more. In recent budgets, the cost of water subsidies has been roughly 73 million dollars (U.S.).

In the past, drops in domestic water use came through moral suasion. When the Israeli public was convinced that the water shortage was acute and genuine, it responded by reducing their consumption. Lawns were dried up and even cemented over, shower times shortened, and water saving devices installed in bathrooms etc. The agricultural sector was also politically more willing to accept water allocation reductions. For example, when Israel's Supreme Court disqualified Spartan water quotas issued by Water Commissioner Dan Zaslavksy in the early 1990s, he was left with little alternative. Zaslavsky made a direct appeal to the public. Given the three successive years of drought that had depleted and overdrawn Israel's fresh water resources considerably he asked Israelis to cut back. The public responded positively. Subsequent to Zaslavksy's request, some 10% drop in overall use was recorded. Albeit, this drop was temporary, as the following above average rainfall years resulted in cut backs to be withdrawn.

In other areas, Israelis have shown an impressive willingness to pay for public natural resources when they felt they were threatened, their crushingly high tax burden not withstanding. For example, in the wake of arson in the Carmel forests, citizens made substantial donations to telethon campaigns designed to cover the replanting expenses (Shechter, 1996). Entrance fees to nature reserves and parks have not excessively deterred visitation rates. As the availability of desalinated water increases, Israelis will, for the first time, be able to manifest their "willingness to pay for water," with a potentially unlimited supply. But there will be a price. Here, societal support for alternative users of water (nature, agriculture) can be expected.

Ironically higher rainfall may have an important role in influencing this particular factor. That is to say, when there is drought, the predictable efforts to galvanise the public to reduce water consumption have varying degrees of success, depending on the integrity of the appeal and the message. During wet periods, however, while basic infrastructure improvements continue (for example dissemination of two tank toilets, etc.) there is less of an actual appeal for restraint and conservation and the issue of demand management remains tucked far away from public consciousness. In other words, a crisis management response dominates the public's behaviour. The challenge is to convert this response to a sustainable one that pre-empts crisis rather than responding to it.

In sum, the water culture in Israel is driven by the hegemony of agriculture that is rooted in Zionist ideology. Demand management and conservation tend to be retroactive and are short term responses to crises and not proactive and long term. Supply side management dominates with special attention being focused on technological panaceas to the water crisis such as the building of desalination plants on the Mediterranean coast and the proposed Red-Dead Conveyance project.

Water Culture in Palestine

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There are several objective differences between the water resources in the Palestinian sector and those in Israel. The most obvious one involves absolute quantities of available water. Israel currently has the upper hand in control of both surface and ground waters of the Jordan River watershed including those areas in occupied West Bank. At the same time, water delivery infrastructure in Palestine is not as developed as it is in Israel. This means that water quality is not as high a concern in Israel as it is for Palestine. The discrepancy in both water quantity and quality is an important factor in the water culture of Palestine. The water consumption patterns by Palestinians is thus due in large part to political constraints.

The most basic disparity between Israeli and Palestinian attitudes towards water can be traced to how much they receive, or "per capita" allocation rates. The average Israeli consumes roughly 350 cm/year while Palestinians roughly 100 cm/year.

In absolute terms, agriculture is a far smaller consumer of water in b Palestine than in Israel. The division between domestic/industrial and agricultural usage is roughly 89 MCM for agriculture with 57 MCM for the domestic sector. Ironically, this makes Palestinian agricultural a *relatively* greater consumer of water than the Israeli agricultural sector. Of course the water management profile of agriculture in the West Bank is completely different than in the Israeli sector. (See chapter 6). For example, irrigation techniques in the West Bank do not rely on capital intensive drip systems, although this depends on the region and crop. Traditional Palestinian reliance on rainfall and streams, along with a lack of an irrigation-based agricultural sector is considered by leading Palestinian experts to have ecological advantages (Assaf, 1994).

Another difference is the relative contribution of surface water to overall resources. For example there are some 527 known springs in the West Bank, providing roughly half of domestic consumption. As these springs historically were not regulated by the Israeli authorities, historic rights remained in force. Some 67% of these streams are utilised – roughly two-thirds by agriculture in the West Bank with the other third used for domestic purposes.

The enormous magnitude of lost water to delivery systems has been documented in a number of contexts) with as much as 30% loss of local waters attributed to leaky pipes. While theoretically, this problem falls in the technological rather than the social realm, expanding water efficiency in the municipal sector through investment in infrastructure is driven by social/political considerations. For example, the hesitancy of Palestinians to rely on Israeli technology can be linked to the general hesitation to allow for ongoing control and influence of Israeli sovereignty of water resources over Palestinian territories and resources.

In general, the relative scarcity of water (both in terms of quantity and quality) in Palestine drives local perceptions and attitudes towards this resource. An additional factor driving attitudes is the traditional use of water in some villages in the West Bank. Where local control of water still remains intact, water allocations for agriculture are socially determined. Unfortunately, these systems are under threat as centralised authorities such as the Palestinian Water Authority begin to assume control. Further, the dominant role of political instability and the recent Intifadah within the day-to-day reality of Palestinians has enormous manifestations for the social dynamics of this society regarding water. In fact, it is a key element in the water culture of Palestine due to the perceived hegemonic position of Israel.

While Israelis are vaguely aware of the geopolitical conflict in the area as a source of tension regarding water allocations, these issues are extremely high in the perceptions of Palestinian communities. The Oslo accords brought with them a spate of public works projects, largely American funded, with the goal of strengthening the water infrastructure of the West Bank. Yet, due to a variety of factors, most of these did not change the conditions on the ground and water scarcity only grew worse. This has surely not been lost on the Palestinian public.

The impact of the military activities of the Israel Defence Forces (IDF) on water infrastructure is frequently cited as exacerbating a situation that was already extremely deficient. The freezing of critical water infrastructure projects (e.g., the sewage treatment plant in Hebron or Sulfit) as a result of the present hostilities suggests that to a large extent there is justification for linking water policies with the broader context of Israeli-Palestinian relations. In a word, for the West Bank, the present round of hostilities affects everything, with water management and perceptions of water issues being no exception.

This point becomes acutely salient during periods of curfew. At these times, water delivery becomes a critical issue for all Palestinian citizens, regardless of socio-economic class. Basic access to drinking water becomes the primary focus of households. Showers and personal hygiene are delayed so as not to waste valuable water. As bottled water is too expensive for much of the population, tap water (or water delivered in tankers for the 200 villages that remain without running water) is the critical resource, and during summer months, supply is sometimes interrupted.

As such, Palestinians tend to blame Israel for water scarcity problems. A pervasive sense of injustice in the allocation of water resources is a common feature of almost all Palestinians' personal ideology, regardless of the individual's political or theological inclinations.

Cisterns and storage of rainwater constitutes a basic element in many Palestinian homes. This direct involvement by citizens, while on the one hand, a form of empowerment, also offers a constant reminder of perennial shortages. In other words, the citizens experience in generating their own water, makes them appreciate the resource and they are acutely conscious of its value. This contrasts with urban residents of Israel that are largely buffered from personally experiencing scarcity, due to efficient water distribution infrastructure.

With scarcity dominating local perceptions, other uses of water are often perceived as frivolous or irrelevant. For example, should a conflict between nature and human needs arise, the acute shortage among Palestinian makes concern for ecological values, or for increased supply to the Dead Sea seem like a "luxury." With the expansion of supply for basic human needs, increasing quantities is considered to be the pre-eminent priority in discussions. A peace treaty that included a redistribution of water for the region that included allocations for nature (as well as generating expanded supply) may be able to change this perception, but only if it also leveraged a parallel increase in water allocations to consumers in Palestine.

Water prices are set at an artificially low level in Palestine in order to ensure universal access, regardless of economic capabilities. Bottled water, although widely available in stores, is only utilised by a small (but growing) percentage of the local population due to the high (relative to income) associated costs. Tap water is sufficiently expensive and in many cases unavailable to justify a variety of "collection" activities by local populations in Palestine, where individuals drive to springs or private treatment centres and fill up containers.

Farmers typically do not pay for water at all in Palestine. Stream-supplied irrigation is received free of charge, due to the persistence of historical rights. This suggests that any direct expenses assigned to them for water usage will have an immediate affect on agronomic decisions and will be unpopular. Unlike Israel where there exists a certain level of animosity towards the agricultural sector for "wasting" limited water resources, Palestinian farmers do not appear to be the subject of resentment by their urban countrymen. The general public is aware of the poor quality of effluents, which are occasionally used by the agricultural sector, and tends to have an "inflated" view of its contribution to irrigation supply. As such, most city-dwellers have little desire to "compete" for these sources of water.

Moreover, there is no "perceived" agricultural lobby driving public policy in water in these sectors as in Israel. The poorly organised subsistence farmers (fellahin) are less likely to wield direct influence in the corridors of power, but at the local level they can be a powerful force (Trottier, 1999). In either case, the political process in Palestine does not lend itself to making water a "hot" political issue in the domestic context, if for no other reason, because of the issue's public persona as one of many areas of conflict involving Israel.

Water conservation constitutes a highly developed ethos in Palestinian society. Regulation of agricultural utilisation is often done via social pressures, with the wasting of water considered to be an inappropriate behaviour which brings with it social repercussions.

There are great gaps in the availability and quality of water in Palestinian societies. Palestinian communities without access to running water are typically more indigent and rural. More importantly, they are more vulnerable to contamination of springs, which provide a sole source of water for the at least 200,000 people in these villages. There are a growing number of reports of utilisation of polluted streams by Palestinians, notwithstanding their classification as a resource unfit for consumption.

Editors' Summary

The cultural contexts of Israelis and Palestinians in the realm water have noted similarities and differences. But they inform and will influence the future discourse about water resource management.

The role of agriculture in each society is markedly different, but the implications for water policy may not be. In Israel ,the commitment to the farming sector constitutes a hold over from Zionist ideology that gave the agricultural sector a preferred status. Despite any economic and social indicators that say otherwise, farming still resonates strongly with the Israeli public. While agriculture's "stock" has dropped in recent years, there remains a pride in Israel's agrarian heritage and a "willingness to pay" for maintaining a verdant countryside.

Palestinians also enjoy a rich agricultural heritage, albeit the role of "irrigation" and high-tech, export-driven farming has never been as salient. There is also is less historic "tensions" between different water using segments as to the legitimacy of the dominant agricultural allocation there. (There are signs, though, that as urban population needs grow, there may be less tolerance for profligate utilization of water by Palestinian farmers.) During the Intifidah periods, when the Palestinian economy imploded, agriculture provided many households with subsistence support. This left many Palestinians with the sense, that at the very least, providing water for agriculture can be critical in tough times for economic and human survival. It can therefore be assumed that any peace agreement will have to maintain reasonable allocations to agriculture. Calls for abandoning cultivation and opting for the "virtual water" that imported produce can provide will probably not be politically palatable in Israel or in Palestine. Yet, the continued transition from fresh to waste water as a source of irrigation waters farmers may find greater support with time.

There is a growing concern among both the Israeli and Palestinian public about the quality of drinking water. This is reflected in the expanded utilization of bottled water. Israel's economic circumstances allow for greater consumption by a larger segment of the population (according to some surveys – over 70%). But sales in the West Bank and Gaza suggest that water is increasingly becoming a consumer product for Palestinian households as well. At present, the issue of water quality from bottled water is not well regulated in the Palestinian sector. (See chapter 5). Given the strong links between the two society's retail economies, this might be an important area of cooperation in the future.

There are also fundamental difference between the two societies' views about water resources. For Palestinians, the ongoing conflict, the occupation and the inequity in supply are important factors that shape their thinking on the subject. Even were there to be plentiful water,(and the promise of desalination may make this possible) Palestinians will most likely still deem it critical to receive Israeli recognition of Palestinian water rights. Israelis are reminded periodically by politicians about the role of water in the Arab-Israeli conflict, but most do not perceive it as a critical issue in the negotiations and the resolution of the geo-political enmity.

Another factor where major cultural divisions exist is in the area of technology and economy. Israel has enjoyed enormous agricultural benefits from computerized drip irrigation systems. Recently, its desalination plants have been called the most efficient in the world. A sophisticated and efficient water supply network so that any discussion of water scarcity and the idea of "running out of water" is a theoretical abstraction to most people. In short, Israel is about as "technologically" optimistic about water supply as any Western nation on the planet. And for good reason. Water supply and for the most part water quality have improved due to the country's faith in water technology. With water technology now identified as a strategic priority for national economic development, this position will only grain strength.

In contrast Palestine water shortages are an everyday part of life that are exacerbated by the occupation. There is a sense that many of Israel's high-tech solutions for waste water treatment and water desalination may be inappropriate at present for

Palestinian society as it lacks the economic resources, and in some cases the human capacity to maintain such a high-input infrastructure. Israel's assumption that "desalination" can solve any water quantity discrepancy will have to address this perception. In addition, some Palestinian express the view that water production facilities are temporary- with limited life spans. Tapping ground and surface water resources is perceived as far more sustainable and desirable as a source of supply.

The two parties' water quantity and quality realities are very far apart. Israel possesses a sophisticated infrastructure for supplying water to all economic sectors consistently with few interruptions in supply or degradation in quality. By contrast, in Palestine, there is minimal infrastructure, frequent disruptions in water supply and often the water quality provided is poor, contributing to public health insults. The reasons behind this asymmetry are well known and well documented and so too is the political nature of the water dispute between Israel and Palestine. Beyond the complexities of the local hydrology, the dispute also involves water rights, nationalism, aspirations for statehood and religious tradition. In short, just as the hydrological picture in the two societies is very different, so are water's modern cultural ramifications.

Part 4. Water Legislation

The legal framework for Palestinian and Israeli cooperation on water issues must address both issues of quantitative allocation of shared water resources and of protection of water quality. Protection of water quality is related to protection of water quantity in several ways.

These two chapters first set out the existing Palestinian and Israeli legal regimes for water quantity allocation and for protecting water quality. They then consider what legal adjustments would be needed to allow the two regimes to work together.

The Palestinian Legal Regime for Water Quality Protection

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Introduction

The legal heritage in Palestine dates far back to various historical eras including the Ottoman rule, British Mandate, Jordanian/Egyptian rule, and the Israeli military orders issued during the Israeli rule and last in the layers, are Palestinian laws and regulations. In respect of water, the various legal traditions have had significant impact on shaping water issues. The Sharia deems water a source belonging to all, i.e., public property held in common. The Ottomans, between the Sixteen-century and beginning of the Twentieth (1917) maintained Sharia principles but established rules for use. During the British Mandate (1917-1948), the same rules remained in operation, but for the first time, concepts involving management were introduced. During the Jordanian rule (1948-1967 in the West Bank) and Egyptian rule (1948-1967 in Gaza), the laws of Jordan reinforced the principle of management of water resources. In Gaza, the British Mandate principles continued unchanged. Effectively, management principles emerged early and became operative in British Mandate Palestine. The Israeli Military Orders (1967-1994) considerably altered the principles of water use and management of water resources.

After the 1967 war Israel declared all water resources in the region as State Property (Military Order 2 of 1967). Military Order (MO) 92 Aug. 15, 1967 transferred the authority over Palestinian Territories water resources to the area military commander and MO 158 Nov. 19, 1967 forbade the unlicensed construction of new water infrastructures. With increased settlement construction in the Palestinian Territories, Israel imposed stringent restrictions on the Palestinians concerning the development of the water resources. These regulations were intended to allow meet the growing consumption which often exceeded supply.

Pursuant to the Interim Agreement signed between the Palestinians and Israelis on September 28, 1995, Article 40 (1), the Palestinian and Israeli sides agreed on transitional measure regarding water issues while they agreed to cooperate to develop programs that address water management, water rights and equitable utilization of joint water resources. Under this Article, Palestinians will purchase water from Israel. A Joint Water committee (JWC) was established to coordinate the management of water and sewage resources systems. The Palestinian Authority commenced its activities through Presidential Decree No. 90 of 1995. This Decree called for the establishment of a Palestinian Water Authority (PWA) with a head and deputy head. In 1996, Law No. (2) of 1996 on the Establishment of the Palestinian Water Authority set the parameters for the PWA and established the National Water Council.

In 2002, the PA adopted the Water Law. This Law was adopted by the Legislative Council following extensive deliberations. The draft law had been initiated in the late

1990s by the Palestinian Water Authority in order to develop a modern and harmonized[9] legal framework for water legislation applicable in the Palestinian Authority. In effect, since 2002, one water law applies in both areas and regulates water-related issues.

Present water administration and regulations in the Palestinian territories, which are stipulated in the Water Law are derived from Islamic water law principles together with concepts and interpretations which have been imposed on pre-existing regulations, local uses and customs. The Water Law encompasses the whole water sector. It aims to develop and manage the water resources, to increase capacity, to improve quality, to preserve, and to protect against pollution and depletion. The Law provides an expanded legal basis for the "Water Authority", and grants it a legal personality

The philosophy of this new Palestinian legislation is that the water resources of Palestine are common public property; they are controlled and managed by the government for the benefit of the people and for the development of Palestine (proposed Article 2). The same Article entrusts the government with the protection of water resources from depletion and pollution. The main highlights of the law are below.

Private Ownership/Licensing Use

The private ownership concept of water resources is altogether eliminated (proposed Article 3). There is only a private right of use. The right to water allocation is linked to a specific use. There is no right to sell or transfer the right even for another private use. Accordingly, and even prior to final enactment, a special transitional/gradual program is under way in Palestine. It is aimed at fundamentally changing the legal concepts that have prevailed for centuries, i.e., land ownership included the right to use the water flowing through the land, beneath it or drawn from wells situated on the land[10]. Under the new legislation, a regime of licensing production and use will replace ownership.

[9] The West Bank and Gaza laws reflect two sets of laws and different legal systems. Thus the PA in 2004 set out to harmonize laws prevailing in these areas to achieve unity and at the same time update legislation.
[10] The Israeli Military Orders laid the ground work for the elimination of private ownership.

The licensing extends to use for landowner's own private consumption. The proposed law allows private water production, pumping and supply.

Public Ownership

There is, equally, no public ownership of water, there is only management.

Beneficial Uses of Water

The legislation defines uses. Water is allocated to specific beneficial uses including:

- Domestic
- Agriculture
- Industrial
- Commercial
- Tourism
- Other private of public uses

These uses must be licensed pursuant to the Law (proposed Article 5(2)).

Licensing

Licensing for special activities is regulated by (proposed Article 4). These licenses include:

- Use license
- Production license
- Recharge license
- Drilling license
- Excavation, extraction, operation and collection license
- Wastewater treatment
- Desalination

2. The Institutional Framework for Water Management in the Palestinian Authority (1995-present)

When the Palestinian Authority took over, the water sector, administration and regulations in the area were severely underdeveloped. However, this water sector was immediately recognized as an important strategic sector. The PA found that the roles and responsibilities in the water sector were scattered, fragmented and unclear during the occupation period which lent itself to inefficient management and uncoordinated investments. In 1995 the Palestinian Water Authority was established by Presidential Decree No.5/1995. It found that there was an urgent need to restructure the water sector in order to regulate, monitor and control the managerial, technical and financial performance at the national, regional and local levels.

Having capable institutions is central to creating a comprehensive water management system. The acuteness of the water crisis in the Palestinian territories requires setting long-term strategies and allocation policies. Like the legal framework, the institutional framework is characterized by numerous agencies that often perform competing duties.

The PWA and the Ministries of Energy and Natural Resources, Agriculture and Health set the environmental standards related to the quality of water for various uses and minimum public health standards. Responsibilities are divided statutorily to the following agencies:

The Palestinian Water Authority (PWA) is an independent entity that aims to efficiently administer the management of water resources and develop them to implement the water policies adopted by the National Water Council, to undertake water projects and supervise their implementation, and to achieve full coordination among the municipal agencies and other distribution bodies. The Council sets the policies and strategies for the management of water resources; the PWA is the administrator and "manager.". The

Cabinet of Ministers, based upon the recommendation of the Council, may issue any regulations that it finds suitable, to implement the provisions of this Law.

Article 7 of the Water Law grants full responsibility for managing the water resources and wastewater in the Palestinian territories to the PWA. In the area of water quality protection, the PWA is tasked with the following:

1. Create reserve areas for protection from the danger of pollution, and exercise oversight and supervision over such areas, and approve transfer of water between the different geographic areas.
2. Study water and wastewater projects, and projects that integrate them, and set design standards, and quality assurance, and technical specifications, and work to control their implementation.
3. Regulate and supervise research and studies relating to water and wastewater, and follow up with the concerned and specialised parties.
4. Participate in setting approved standards for the water quality for the different usages in cooperation with the relevant parties and insuring promulgation.

Ministry of Health: Responsible for public health aspects, water quality standards and the alleviation of water related health risks. In the Gaza Strip this Ministry conducts all the water quality testing.

Ministry of Local Government: Responsible for local (urban) planning, organisation of the operation of the systems via the Municipalities and participates in hearings regarding licensing.

Ministry of Planning and International Cooperation (MOPIC): Holds a mandate for the coordination of international cooperation and national planning issues. Its Directorate for Urban and Rural Planning (DURP) is responsible for overseeing the general policies, plans and programmes for the spatial planning at the national and regional level.[11]

[11] The MOPIC is now separated into two different ministries, The Ministry of Planning and The Ministry of Foreign Affairs.

Environmental Quality Authority: Responsible for environmental policies, strategies, and criteria to ensure ecological and environmental sound development of the surface water and groundwater resources.

Palestinian Legislative Council (PLC) - The council has a mandate to recommend for the enactment of different regulations and bylaws.

The Ministry of Justice (MoJ) - This Ministry has a mandate with regards to justice and legal enforcement.

The National Water Council (NWC) is responsible for overarching water policy and strategic matters. The council consists of the president of the National Authority as Chairman and members from the ministries, municipal, and private sector representatives involved in water issues, with the PWA as Secretariat. The main objectives of the Water Council are to approve the National Water Policy and to support the work of the Palestinian Water Authority.

3. Legal Rules on Water Quality

The Water Law of Palestine, like that of Israel, sets out general standards for protecting water quality. The various agencies and ministries are tasked with setting more specific standards. The PWA (The Authority) is the primary agency for implementing water quality standards. Currently the PWA acts upon the principles of the Water Law; it has developed a master water plan; it coordinates with various PA agencies and ministries on the various uses of water and the applicable rules; especially the Ministry of Agriculture and the Environmental Protection Authority; it has embarked on preparing the water regulations which include licensing for use, abstraction, well drilling, among others.

There remain, however a number of impediments that keep the PWA from going beyond the preliminary stages of developing specific regulations. Among the greatest of these obstacles is the magnitude of coordination with the Israeli side that is still required. Other factors include the nature of acquired rights, inherited over decades and passed on from one generation to the next. Altering and restricting use has been a daunting task for the PWA. Another factor is enforcement. The PWA lacks the tools and means to enforce the laws and its regulations against violators which permits breaches to go unsanctioned. Other impediments included limited financial and human resources that are available to the PWA to enforce the law.   The PWA lacks the technical means to monitor use and hold accountable. The water infrastructure is underdeveloped in the PA which precludes effective and efficient monitoring.

A. Water Quality Standards

The Water Law empowers the Authority to carry out the following actions for the protection of water resources and the prevention of pollution.

1. Participate in regulating the use of agricultural and industrial materials, which may cause pollution to the water resources or its supply systems. The PWA coordinates with the Ministries of Agriculture, Health, Local Government, National Economy[12] and the Environmental Protection Authority to regulate and prevent pollution and issued standards for quality of drinking water[13] and wastewater standards.[14] The PWA uses this authority to test and verify and enforce the standards. The PWA relies on monitoring and notices in events of violations. It works closely with local government units (municipal and village councils to enforce the standards and educate).

2. Participate in preparing special guidelines for the environmental impact assessment for any activity relating to water resources or their supply systems. The PWA in cooperation with 12 ministries and agencies like the EQA, Health, Agriculture, and Local Government adopted in 2000 the National Environmental Impact Assessment (NEIA) Policy. The Policy addresses national and local environment impact issues regarding all types of activities and projects. A national committee comprised of the relevant ministries and agencies sanctions these assessments.

[12] Industrial licenses are issued by the Department of Industry at the Ministry of National Economy.
[13] Palestine Institute of Standards rules: (PSI 41).
[14] PSI 742.

3. Participate in preparing special mechanisms for crisis management when there is draught, flooding or a plague that is spread via water, or in response to major pollution events. The PWA participates and plays an active role with the EQA and the Ministries Health and Local Government in preparing the mechanisms for crises. They participate at the national level and the local government level, working in remote areas to provide water in events of draught or take active measures in case of flood or there might be bacteriological contamination that might be found in areas where raw waste water is used for irrigation..

4. Participate in preparing a list of pollutants, whose discharge requires licensing, and compensation for damages resulting therefrom.[15] The PWA has prepared the list of water-related pollutants. The notion of licensing pollution exists in the Environmental Law, but the notion of polluter pays is not yet prevalent.

B. Effluent Standards

The Authority may halt the production or supply of water if it appears that its source or supply system is polluted and it may close the source or system if pollution continues.[16]

C. Work Practice Standards, Equipment Standards, Prohibitions for Water Supply

The PWA is responsible for supervising well drilling and qualifying contractors in the field of constructing water facilities in accordance with procedures that are set by the law.[17]

D. Specific Legal Instruments Regulating Water Quality

[15] Water Law of 2002, Art. 29.
[16] Water Law of 2002, Art. 30.
[17] Water Law of 2002, Art. 7, Sec. 9.

Beyond the 2002 Water Law, several scattered statutes affect the normative framework for regulating water and are worthy of brief mention:

Public Health Law No. 20 of 2004: This Law authorizes the Ministry of Health to supervise public sewage networks and wastewater treatment facilities.

Environmental Law No. 7 of 1999: Chapters Three and Four of this Law empower the EQA to safeguard water and marine environmental quality. The rules prohibit the disposal of materials and substances in sewage systems or sea water.

City Planning Law No. 28 of 1936 (applicable in the Gaza Strip): This Law requires a building permit and the approval by municipal/local government units of the construction of building, roads, and public and private sewage systems. Any construction or sewage system, etc must be in compliance with the national and local plans which proscribe causing any harm to the environmental.[18] The PWA, EQA and local Government all must give prior approval to such projects.

Building and Planning Law, No. 79 of 1966 (applicable in the West Bank): This Law is far more sophisticated that its counterpart applicable in the Gaza Strip due to the timing of its enactment. Therefore, it has express and clear language prohibiting water pollution and safeguards for sewage controls. On the other hand, all construction at all levels (national, regional and local) must obtain a license and the same is true for water and sewage connections. The same is true of cesspool, and septic tanks.

Municipal Sewerage Law No. 1 of 1936: This requires the construction of sewerage networks and have all buildings and homes connected to the networks. The Law further requires and authorizes local governments to set up and operate sewage collection and treatment systems. It further call for the prevention of pollution of water resources.

[18] The reference to environment issues in the law is in passing. It is a date law where such issues when the law was adopted were not examined. See by contrast, the equivalent law in the West Bank which is more detailed and refers to prohibitions against pollution. In practice today, the National Environmental Impact Policy bridges the gaps in the law and the same is true of the Environmental Law which applies in both the West Bank and the Gaza Strip.

Municipal and Local Government By-laws: Local governments have authority under various national laws to enact local bylaws on issues of water quality. Many local governments have enacted such bylaws, particularly in the area of pretreatment requirements for industry. In addition to the laws mentioned above, several other statutes address water quality issues. Once such example is the Drainage and Flood Control Ordinance of 1941. Other sources of legal authority include regulations that have been issued pursuant to the various laws listed here or the standards adopted.

D. National, Regional, Local and Detailed Plans

The aforementioned National Water Plan of 2000 constitutes a strategic blue print for the water sector. It sets the general direction and objectives until the year 2025, and proposes actions to be taken to achieve these goals. The document describes the role of service providers. It holds that regional water utilities will be responsible for the following services: preliminary investigations and design; construction and/or rehabilitation; research; repairs; operations and maintenance. Moreover it states that services would cover the fields of municipal and industrial water supply; waste water collection treatment and re-use; storm-water collection, treatment and re-use; water and treated wastewater supplies for irrigation. Until all the regional water utilities are established, the PWA is to maintain responsibilities in these areas. To date, only the Coastal Water Utility is established and operates.

The PWA has overall responsibility for wastewater treatment and licenses treatment facilities and undertaking supervision and regulation. The PWA has prioritized the establishment ofinfrastructure for the treatment of wastewater, but not all wastewater is treated at present. The PWA has a number of plans ranging from annual plans to 3 or 5-year ones that emanate from the National Water Plan and address issues like wastewater treatment, among other topics as mentioned above. There are no penalties for lack of treatment at present because not all areas are serviced and have wastewater treatment facilities.

4. Methods of Implementation

A. Business Licenses and Building Permits

The PWA is responsible for licensing the exploitation of water resources including the construction of public and private wells and their regulation, water exploration and drilling, testing and production wells, and any other matters or activities relating to water or wastewater, in cooperation and coordination with the relevant parties.[19] As mentioned above, the PWA licenses wastewater treatment facilities, but it is the Ministry of Health and the EQA that are responsible for industries that discharge polluted effluents. All industrial facilities receive a license to operate from the Ministry of Health. The National Committee overseeing the EIA Policy requires the relevant ministries and agencies to issue the required licenses and ensure that the emission of effluents is monitored and inspected. Further, the EQA inspects licensed facilities and has adopted schemes and issued instructions for related standards.

5. Penalties for Non-Compliance

Article 32 requires anyone who causes pollution in any water resource or its supply system to remove the pollution to that source or system at his own expense. In the event that he/she refuses or fails to do so, the Authority must remove the pollution and carry out the cleaning operations. This is done at the expense of party causing the pollution after notifying him of this, regardless of the costs, which shall be levied upon him in accordance with the Law for Collecting Public Monies.

[19] Water Law of 2002, Art. 7, Sec. 5.

The Water Law imposes criminal penalties on violations of specific provisions which include fines and imprisonment. These include:

1- Polluting any water resource or supply system, or causing such action and failing to redress it within the period set for him by the Authority.

2- Drilling ground water wells without a license or contradicting the terms of the license issued to him.

3- Violating any water resource or sewage system, causing it damage or leading to its destruction .

4- Supplying water to or permitting the supply of water to oneself or to others without a license to do so.

The penalties for the above violations range from one month to one year in prison and fines of up to five thousand dinars.[20] The penalties are doubled for repeat offenses.[21] Article 37 of the Water Law provides the judiciary with the discretion for adding additional penalties, including requiring payment of the cost of the damages and clean up.

Issues related to water pollution enforcement have not yet reached the court system, as such there is no precedent or direction from the courts on water pollution.

A. Enforcement by the State

The Authority has the right to inspect water resources and systems of supply, and any place where pollution is suspected. The associated legal authorities include the right of

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[20] Water Law of 2002, Art. 35.
[21] Water Law of 2002, Art. 37.

entry into any private or public property or building to accomplish this purpose in accordance with proper procedures.[22]

B. Enforcement by Local Governments

The PWA and water utilities are charged with ensuring continued service to their local populations. The lack of specific regulations and a weak infrastructure, however, make enforcement at the local level very difficult. The Minister of Local Government and a representative for the regional utilities are included in the National Water Council and provide a voice for local concerns.

C. Enforcement by Private Parties and by NGOs

Multiple environmental organizations have come into being which act as watchdogs and a voice for the public. The National Water Council also provides a seat for a representative of the Water Unions and public societies as well as Palestinian universities. Organizations working in the water and environmental sector are numerous, conducting considerable research and contributing to public awareness. Typically, they collaborate with the PWA and other related government bodies in preparing the standards, working during periods of crises and providing support and awareness to schools and the public and participate in administrative forums. However, NGOs and civil society play no role in taking public or private polluters to court.

D. Enforcement by the State

Criminal Enforcement: The Water and Environmental laws both set out criminal provisions for violators who many be subject to both fines and imprisonment. Specially, the Water Law lists 6 incidents of violations including causing pollution to water resources where penalties and/or imprisonment may be imposed. It law requires the violator to pay and remove the pollution. The Environmental Law stipulates similar provisions. Enforcement is limited.

[22] Water Law of 2002, Art. 34.

6. Groundwater Protection

The Water Law expressly sets out provision for declaring an area containing ground water a protected area, if the quality or quantity of water is in danger of pollution, or if carrying out the water policy requires such action, on condition that it provides alternate water resources. In this respect, the Palestinian Water Law is in line with present Israeli Law.

7. Water Re-Use and Water Quality Protection

The PA has not yet developed water re-use policies.

8. The Mediterranean and Dead Seas

The Water and Environmental Laws are expressly clear that water and marine environment shall be safeguarded from discharges into the sea,[23] whether directly or indirectly.

9. General Comments

Palestine has developed the national, regional and local plans for controlling water pollution. It has adopted a system for licensing use of water sources and placed stringent restrictions on water pollution. Three national government ministries/agencies are involved: the PWA, the EQA and the Ministry of Health. At the local government the Ministry of Local Government has oversight through municipalities and villages councils and other local government units. Through the National Water Plan and its subsidiary plans as well as the National Environmental Impact Assessment Policy, governmental bodies monitor and supervise water quality and seek to enforce against pollution of water and water resources. Enforcement of the legal requirements is emerging, but requires considerable strengthening. Enforcement through the courts is not practiced yet. A number of local and international environmental NGOs work in water and environmental fields especially in the area of public awareness. For the most part,

[23] At present, the Dead Sea in not accessible to Palestinians.

they do not serve as watchdogs against polluters nor do they have the authority to take violators to court.

Legal Framework for Allocation of Water and for Protection of Water Quality in Israel

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Water Quantity Allocation

1. Water Ownership: All water sources in Israel are designated by statute to be public property, subject to control of the State. The State is to exercise its control in a way that serves the needs of the residents of the state and development of the country. No individual has rights in water except as provided in the Water Law of 1959; ownership of riparian or other real property carries with it no water rights.

2. Laws:

Water Law, 1959: This is the main statute on allocation of water quantity. Several other laws supplement the authorities provided in the Water Law. These include the Water and Sewage Corporations Law, 2001; the Supervision of Water Drilling Law, 1955; and the Water Measurement Law, 1955.

3. Institutions:

Government Water and Sewage Authority (Water Authority): The Water Authority administers the statutorily established system of rights to use fresh water. It is headed by the Director, who is appointed by the Government upon the recommendation of the Minister of National Infrastructures.

Water Council: The eight-member Water Council operates within the Water Authority. It supervises Water Authority policies and their implantation in such areas as water pricing, extraction, licensing etc. Five members of the Council represent governmental ministries, and two, appointed by the Government, represent the public. The Director of the Water Authority is the chairperson.

Water Court: This administrative court has authority over issues arising under the Water Law

4. Policy and Planning: Water allocations policies are partly controlled by the Water Law. In addition, both the Government and the Water Council have a role is setting water policy, subject to the provisions in the statute.

5. Legal Requirements: The Water Law, 1959, sets out a complex scheme for allocating rights to use water. Anyone seeking to use water must obtain the "right to use" under that scheme.

6. Implementation: The allocations are implemented through a system of permits.

7. Enforcement: Those who use water without complying with the law are subject to administrative and criminal enforcement.

Water Quality Protection

1. Basic Character of Water Quality Protection Scheme: While the legal regime for water quantity allocation is found mainly in one statute, the legal scheme for water quality protection is scattered among several different statutes. There are probably a number of reasons for this less than unified approach to water quality. Because of the arid nature of the region, the need to deal with water quantity allocation quickly became clear with the growth of population after the establishment of the State in 1948. Israel could support its growing population, agriculture, and industries only with careful use of its limited water supplies. The need to deal with water quality issues was recognized more slowly and brought about by two factors: the growing awareness of the importance of water quality protection throughout the developed world, and the increasing pressure the growing population put on the quality of Israel's water resources.

Main Regulatory Laws

2. Laws: A large number of laws deal with water quality. They invoke different approaches to sometimes similar problems and scatter authority among a variety of administrative agencies.

Water Law, 1959: In 1972, provisions on preventing pollution were added to this law. These were later amended several times to reflect increasingly stringent policies.

Public Health Ordinance: This statute authorizes protection of water quality where water quality deterioration has an adverse impact on public health. Most water pollution has an adverse impact on public health, so the reach of this statute is broad.

Business Licensing Law, 1968: A business that is likely to have an adverse effect on water quality must have a business license. Water quality protection provisions are included in the license.

Building and Planning Law, 1965: Any building must have a building permit before construction and must be constructed in compliance with National, Regional, Local, and Detailed Plans. New projects such as roads must also comply with these plans. The law requires consideration of environmental matters in approving plans, sometimes through preparation of an Environmental Impact Statement and sometimes through other, less formal, means. As a result, new buildings and projects should receive approval only after their effect on water quality has been considered.

Law on Prevention of Sea Pollution from Land-Based Sources, 1988: This statute addresses discharges directly to the Mediterranean, the Dead Sea, or the Red Sea (via the arm called the Gulf of Eilat by Israel and called the Gulf of Aqaba by other states in the region), and also discharges to fresh water streams that flow into these bodies of water.

The law sets up a system of specific permits separate from those issued under the Business Licensing Law.

Local Authorities (Sewerage) Law, 1962: This law authorizes local governments to set up and operate sewage collection and treatment systems.

Local Bylaws: Local governments have authority under various national laws to enact local bylaws on issues of water quality. Many local governments have enacted such bylaws, particularly in the area of pretreatment requirements for industry.

Other: In addition to the statutes listed above, several other laws address water quality issues in more specific contexts. These included the Lake Kinneret Ordinance of 1947 and the Drainage and Flood Control Law of 1957. Other key sources of legal authority are the many regulations that have been promulgated under the statutes listed here.

3. Institutions:

The allocation of authority among different agencies is based partly on rational allocations of authority and partly on the basis of political struggles for control over bureaucratic power. In some cases, the authority to deal with certain types of environmental problems resides in agencies that do not see their primary mission as environmental protection. Treatment of many environmental problems is complicated by the need for concerted action by many different agencies.

Ministry of Environmental Protection: The Minister of Environmental Protection has regulatory authority over water quality protection under the Water Law, the Business Licensing Law and the Public Health Ordinance, subject to those areas that are carved out as being under the authority of the Minister of Health or the Water Authority.

Government Water and Sewage Authority (Water Authority): The Water Authority has primary responsibility for administrative enforcement of Water Law's water quality provisions. The authority to issue regulations on water quality remains primarily in the hands of the Minister of Environmental Protection, although coordination with the Water Authority is required.

Ministry of Health: The Minister of Health has authority over the quality of drinking water, including control of water resources designated for use as drinking water. Because so much of the water is used for drinking, this is an extensive authority. In addition, the

Minister oversees the quality of sewage discharges, both before and after their treatment in wastewater treatment facilities. Wastewater reuse standards for agriculture are also set by the Ministry of Health. Israel reuses 77% percentage of its treated sewage, so the authority over those waters is also important.

Ministry of Interior: Local governments derive their power from the State and are subject to State control. This control is exercised largely through the Minister of Interior, who oversees a large portion of local government budgets, approves local bylaws, and local government actions under a variety of laws, including those governing water pollution control. As a result, the Minister of Interior is involved in many important local government actions involving water pollution prevention and control, such as construction and operation of water treatment facilities. In addition, the Minister of Interior has extensive responsibilities under the Building and Planning Law.

Committee for Granting Permits: This Committee operates under the Law for Prevention of Sea Pollution from Land Based Sources. The committee comprises representatives of seven Ministries and one representative of the recognized Israeli environmental non-governmental organizations (NGOs). The Minister of Environmental Protections is the chairperson of the Committee.

Planning Commissions and Councils: Authority for plan development and approval is in the hands of the Local and Regional Planning Commissions, the National Planning Council, and their subsidiary bodies.

Local Governments: Municipal and regional councils are both forms of local government in Israel. Local governments hold four types of authorities that are crucial to protection of water quality. They administer the business licensing scheme under the Business Licensing Law; they comprise the local planning commissions under the Building and Planning Law; they operate many of the country's sewage treatment systems; and they enact and enforce their own bylaws on water pollution control.

4. Policy and Planning: The National Planning Council has enacted 30 National Plans, some of which still require further additions or revisions. Several plans have direct impacts on water quality; these include the National Plan for Impoundment, Infiltration and Utilization of Surface Water, the National Plan for Waste Disposal, and the National

Plan for the Water System (Waste). Other national plans, such as the National Integrated Plan for Building, Development, and Conservation, have more indirect, but still important, impacts. Regional plans must be consistent with all National Plans, providing a greater level detail for zoning in the country's six planning regions. Local Plans must be consistent with all the applicable Regional plans and add yet a greater degree of specificity. Detailed Plans, for specific projects, must be consistent with the applicable Local and Regional Plans and have the highest degree of detail. Regional, Local and Detailed Plans have significant influence over planned projects on water quality.

Under the planning rules, if a plan is likely to have a substantial adverse effect on water quality, an Environmental Impact Statement must be prepared along with a proposed plan or amendment to a plan. The Statement must be considered in deciding whether to accept, modify, or reject the provisions in the proposal. The regulatory requirements are quite detailed, with provision for less formal methods for considering environmental impacts when impacts are less significant. Courts have been fairly strict in requiring planning institutions to observe these environmental consideration provisions.

In addition, significant elements of water pollution control policy are set out by the Ministry of Environment and the Ministry of Health.

5. Legal Requirements: The Water Law, on its face, prohibits any change in the quality of any surface or underground water, whether that water is natural or is an artificially created body of water and whether it is clean or already polluted. Of course, in practice this broad and absolute prohibition is subject to many exceptions. In general, only water pollution that violates a rule, license, permit, or order, or is otherwise unreasonable, is prohibited.

Public Health regulations set water quality standards for drinking water and proscribe the use for drinking water of water sources not meeting those standards. The regulations do not require clean up of substandard bodies of water, but only prevent their use as drinking water.

The discharges of various industries and of sewage treatment facilities must meet regulations that limit concentrations of biological oxygen demand and of suspended solids. For large facilities, the regulations set out the discharge limitations. For smaller facilities, the Director General of the Ministry of Health sets out the limitations on a case by case basis. As is described in chapter 8, sewage treatment standards are being upgraded to require tertiary treatment of wastewater. In addition, a variety of regulations provide more specific requirements for particularly troubling types of industries and practices. These include requirements to engage in certain practices designed to prevent pollution or to avoid certain polluting practices as well as requirements to use certain types of pollution control equipment. The number of such rules is too great to enumerate in the present context. A listing of just some of them provides of sense of the breadth of their coverage. Rules of this type apply to use of chemical spraying equipment and fertilizers, detergents, operation of cesspools and septic tanks, gas stations, and the electroplating industry.

Sources discharging to the Mediterranean, the Dead Sea, or the Gulf of the Red Sea must meet additional regulatory requirements. These regulations require that all such dischargers must have a special permit, and that no permit shall be granted if there is an economically viable alternative of on-land disposal. Permits that are granted have detailed requirements on the amount of pollutants allowed in discharges and on the location of the discharge. In theory, these requirements apply to any discharge that would eventually reach the specified bodies of water, even through indirect means. In practice, indirect discharges are not always subjected to the requirements.

6. Implementation: Most sources of water pollution must obtain a building permit, a business license, or a marine discharge permit. These permits require the source to comply with all statutes and rules and may set out addition water quality requirements. Building permits are issued by local planning authorities, with input from the Ministry of Environmental Protection through the EIS process for projects likely to have a significant impact on water quality. Business licenses are issued by local governmental authorities, with permission from the Minister of Environmental Protection for business that may have an adverse impact on water quality. Marine discharge permits are issued by an inter-ministerial Committee for Granting Permits.

7. Enforcement: All of Israel's environmental laws can be enforced in a variety of ways. They are subject to enforcement by the State of Israel and its national administrative agencies, by the local governments, and by private individuals. Enforcement may be through criminal sanctions imposed by courts, through administrative remedies imposed by the national or local governmental authorities, or through civil orders issued by courts.

Until recently, the State rarely took action against water polluters, while in those cases that were brought, the courts imposed insubstantial fines and hesitated to incarcerate offenders of environmental laws. The number of cases prosecuted has now increased substantially, although it is still debatable whether the number of enforcement actions is adequate. Larger fines have become more common in the last few years. The largest fine for a water pollution that had been imposed at the time of this writing was about $195,000. Most water pollution fines have been considerably lower, raising questions about the implementation of the “polluter pays” principle in practice.

If a corporation or local governmental unit violates the law, corporate officers, public officials, and facility managers are also subject to fines and imprisonment. In fact, individuals are rarely penalized for violations, although the threat of individual liability may lead the corporation or local government to agree to pay a penalty in return for dismissing claims against individuals. In a criminal action, courts may also order the polluter to clean up the pollution and to undertake other specified actions.

Administrative enforcement under the Water Law is problematic. Although the Minister of Environment has general authority for the water pollution control, authority to issue administrative orders is in the hands of the Director of the Water Authority, who has no formal connection to the Minister of Environment.

The administrative authority under the Business Licensing Law is very important. It allows issuance of an administrative order to close a business that is violating its business license or that is operating without a business license. This can provide immediate relief from water pollution.

Israeli law is unusual in that it allows private criminal enforcement of environmental laws. Standing to bring private criminal enforcement actions under the Water Law is granted to anyone adversely affected by violation of the laws, as well as to established environmental NGOs. Few such cases have actually been brought. Management of a criminal case is complicated. Furthermore, the successful plaintiff does not necessarily get a personal remedy for any injury suffered, so the financial incentive for a private person to bring such an action is weak.

A person who has been injured or might be injured by water pollution can seek a court order to stop the pollution under a special civil statute on environmental enforcement. Under the same law, such actions can sometimes be brought as class actions. Neither provision has been used extensively for any type of environmental problems; individuals who are bothered by pollution usually want financial compensation, which is not available under this law. Civil nuisance claims and other tort claims are also available and there are a greater number of such cases, although the problem of proving that a specific polluter caused a specified harm can be daunting.

Israeli law allows individuals to bring civil actions against governmental authorities for failure to observe any legally imposed requirements. In the water pollution control field this is important because it allows private actions against local governments that cause water pollution by their failure to operate adequate wastewater treatment facilities. Environmental NGOs have brought such actions.

Groundwater Protection

Israel has no separate legal scheme for preventing groundwater pollution, nor does it have specific statutes on soil pollution, although proposed laws on these topics are now under consideration. The general legal scheme on water pollutiondescribed above applies to pollution of groundwater as well as surface water, although proof of causation of groundwater pollution is more difficult than proof of causation of surface water pollution. In addition, several laws apply to solid waste or toxic waste disposal. These laws are designed in part to prevent seepage of waste material from a disposal site through the soil into underground water and resulting contamination of the underground water. Such laws include The Law on Preservation of Cleanliness, 1984, which prohibits unauthorized disposal of waste on public and private property, and the Business Licensing Regulations (Disposal of Waste from Hazardous Substances), which require that most hazardous wastes be disposed of in a special facility Ramat Hovav in the southern part of Israel. Both laws are administered by the Ministry of Environment. In addition, under the Building and Licensing Law, conditions designed to prevent groundwater pollution are imposed on new solid waste disposal facilities. These conditions include installation of liners below the disposal cells and of wastewater collection and treatment systems.

Water Re-Use

Much of Israel's sewage is treated for reuse in agricultural irrigation. In a water poor country, this reuse is essential. There are several water quality implications for this system. On the one hand, reuse of sewage brings with it the danger of increasing pollutants such as salinity, nitrates and pathogens. If polluted water is used to irrigate plants, the pollution can enter surface and ground water. On the other hand, by reducing use of Israel's existing water resources, reuse helps save water for other uses. Rules enacted under the Public Health Ordinance provide that untreated effluents cannot be used for irrigation, and that treated effluents can be used for irrigation only if the treatment meets the requirements set out by the Director General of the Ministry of Health. (See Chapter: 7)

The Dead Sea

All laws described above apply to water flowing into the Dead Sea. Most importantly, the Law on Prevention of Sea Pollution from Land-Based Sources, 1988, and rules enacted under that statute apply to all discharges into the Dead Sea, whether they reach that body of water directly or indirectly.

General Comments

Israel has an extensive and complex system for controlling water pollution. This system covers most significant sources of water pollution and involves a number of different types of licensing and permitting schemes. Authority for operating the system is spread through a substantial number of governmental agencies. Enforcement of the legal requirements, while not as strong as some would wish, is well established. In addition, a number of Israeli environmental NGOs operate as watchdogs over the system, working through the administrative agencies and through the courts to see that legal requirements are implemented and enforcement is taken against the most prominent violators. These organizations are working to establish a broad expectation that the law will be observed. The last few years have seen increasing efforts by the State and its agencies to enforce water laws and increasing willingness of the courts to impose meaningful penalties on violators.

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Water Law of 1959

Authors' Summary: Harmonization Requirements

Water Quantity Allocation: It is assumed that water quantity allocation will be addressed in an agreement between Palestinians and Israelis, and that such an agreement may require changes in the existing domestic legal rules of both parties. For the most part, both entities have legal regimes in place for water quantity allocation, and these could be used to divide up the amount of water the entity receives under any agreement. The two legal regimes differ in that there are private water use rights under the Palestinian regime but not under the Israeli regime, but these use rights can be controlled and even extinguished by the central authority. It is likely that with the shortage of water, both regimes will have to alter current allocations of rights to use water, and doing so may create either a legal or political need for compensation.

Water Quality Protection: It is likely that water quality will continue to be the subject of mainly domestic law. Because Palestinians and Israelis share many of the water resources, and the failure of either to protect water quality severely affects both parties, it will be essential to find a way to make the two systems for water quality protection compatible. This will be especially important in cases where the actions of one side affect the water quality of the other side, such as in the following cases:

- Wastewater disposed of in one area that reaches the other, either via the surface or through shared groundwater;
- Land disposal of solid waste or building construction in one area that can pollute shared groundwater sources;
- Joint planning for water pollution prevention projects.

Coordination of water quality standards will be essential. Israel traditionally has taken a position which expects the Palestinians to meet Israeli requirements, even as compliance with them in Israel and in Israeli West Bank settlements is frequently deficient. Environmental expectations must be adjusted to meet available capacity. To some extent, the answer to this quagmire involves phasing in more stringent performance standards through realistic timetables. Just as East German industries were allotted several years to meet the higher West German environmental expectations after unification, Israelis and Palestinians will need to agree that Palestinians need a grace period to allow for the improvement of both the physical infrastructure and human capital. Here the role of donor nations in providing resources directed specifically to this goal will be critical. Another possible model is that provided by the U.S. and Mexico cooperation in restoring their shared water resources. Given compelling American interests in environmental improvement, the U.S. demanded higher levels of performance but was willing to participate in the associated investment within Mexico.

While it will be hard for Israeli environmentalists to swallow, it may also be prudent to accept somewhat less stringent standards in the interest of ensuring high compliance levels. The alternative could be creating a pattern of “lip service” and alienation from shared environmental standards for years to come. The primary legal challenge at present involves implementation and compliance monitoring. The pervasive use of raw sewage by some Palestinian farmers and the excessively polluted discharges of industrial and municipal facilities in Israel are examples of the gap that exists between theory and practice.

One difference between the Palestinian and Israeli system for protecting water quality lies in the licensing arrangements. In theory, any business or operation in Israel that is likely to cause water pollution needs a license of some sort that will include pollution prevention provisions; therefore, the regulatory authorities have prior knowledge of any such operations and the specific conditions that apply to a business are set out specifically. Under the Palestinian system, the law sets out general prohibitions on water pollution but no licenses are required. This can make it more difficult to identify and account for all potential sources of pollution and can leave unclear the precise way the general legal requirements apply to specific sources. Both of these characteristics are problematic in the search for greater transparency between the sides. In practice, the Israeli regime does not work as well as it should, and many businesses operate without business licenses or in violation of them. It is recommended that both sides put in place and operate a comprehensive scheme for licensing sources that may pollute the water, that both vigorously enforce the licenses, and that both licensing provisions and enforcement efforts be transparent to everyone on both sides.

At present, only Israel makes substantial use of treated wastewater and has water quality standards for the treated wastewater. If wastewater treatment is undertaken by the Palestinians, it too will need treatment standards. Coordination of the standards for treated wastewater will be necessary where the treated wastewater can flow as runoff from one area to the other, or where it reaches a shared groundwater resource. In other cases, each entity can set its own wastewater treatment standards.

Enforcement:

The law is only effective when it is observed, and neither compliance nor enforcement is sufficient on either side. No legal system has the funds to catch all violators. The goal of environmental regulatory system on both sides therefore must ultimately be the creation of incentives for polluters not to violate environmental laws. This is the heart of a deterrence system.

At present, the Palestinians find the political situation and pervasive poverty inhibit strong enforcement. It is not now clear whether a change in the political situation would be sufficient to bring about strong and consistent enforcement of the water laws. The Israelis also have a serious enforcement problem, based on a lack of a tradition of fines large and consistent enough to deter violation of the environmental laws, although recent steps are ameliorating, but not eliminating, this problem. Both sides must greatly improve their enforcement of legal requirements, whatever the obstacles. Otherwise, the existing water resources will be overused and polluted, and mutual blame will continue in a way that displaces the accountability that cooperation will necessitate.

Transparency:

Israel has in place a wide reaching Freedom of Information Law, although agency responses to requests for information are not always timely and complete. The Palestinian Authority is working on a Freedom of Information Law. Such laws on both sides are essential to allow the building of trust needed to deal with the shared water resource. Both the Palestinians and the Israelis have active environmental NGOs. These groups should be encouraged to use their respective Freedom of Information Laws to monitor official action, and to share their information with each other.

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[39] The effects of climate variability are exacerbated by the underdevelopment of water resources infrastructure. Without aggressive strategic programs that include storage infrastructure development, vulnerability cannot be overcome.

5) Groundwater Management

Much of the literature involving "water conflict" and the need for joint management between Palestinians and Israelis has focused on the Mountain aquifer, which is shared by the two parties.. This series of three aquifers contains the highest quality water of the natural reservoirs in the region and constitutes the only meaningful source of water for Palestinians in the West Bank. These two chapters offer a review of this critical resource by two hydrologists who for many years been involved in research about water quality and the hydrological properties of the aquifer.

The Mountain Aquifer: Shared Groundwater Resources Environmental Hazards and Technical Solutions

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Background:

The dispute between Israelis and Palestinians over the shared water resources of the Mountain Aquifer is one potential obstacle in the path of peace in the Middle East. One of the largest freshwater sources in Israel and Palestine authority is the Mountain Aquifer, is a particularly vulnerable resource. This aquifer is the only source of water for Palestinians in the West Bank and provides about 50% of Israel's drinking water Due to the chronic groundwater deterioration occurring within the coastal aquifer, the significance of this water source appears to be increasing.

The majority of the Mountain Aquifer's natural recharge area lies within the West Bank territories, with two of its three basins flowing naturally towards Israel. In 1967, Israel occupied the West Bank and imposed strict control policies over the utilization of the Mountain Aquifer water. This policy aimed at preventing irresponsible drilling and groundwater exploitation by citizens which could lead to salt water intrusion. Due to hydrological characteristics, it is vulnerable to additional sources of groundwater pollution.

The geology of this mainly limestone aquifer is complex — water flows in several directions and quite rapidly for an aquifer. But in the main section of the aquifer, the flow is from east to west, which means that in many cases, the actual recharge takes place in Palestinian areas and the outlets are located in Israel. Ninety percent of the catchment lies under the West Bank and sixty to seventy percent of the storage potential lies under Israel's pre-1967 borders. This asymmetry is the basis for the continuous disagreement over water rights and constitutes a challenge for future management strategies.

Along the mountainous backbone of Judea and Samaria mountains, the subsurface water divide is determined by structure, stratigraphy and karst developments, creating two groundwater basins. The western one is known as the Yarkon–Taninim basin (Fig. 1) in which groundwater flow in the mountain aquifer, of Cretaceous age. This aquifer is a major resource of fresh water for both Israelis and Palestinians. The groundwater of the eastern basin, flow to the Dead Sea-Jordan Valley is fully exploited by pumping wells, which supply fresh water both Palestinian and Israeli settlements. In the Yarkon–Taninim basin, the mountain aquifer contains groundwater of low salinities 100 mg/l Cl, (Weinberger et al., 1994).

The mountain aquifer succession is composed of a thick (600–800 m) sequence of hard, karstic (cracked) and permeable limestone and dolomite interbedded with argillaceous beds of lower permeabilities. Such low-permeability rocks separate the upper and lower parts of the Judea Group sequence, thereby creating two aquifers (Avisar et al, 2001):

(1) The lower sub-aquifer, composed mainly of massive dolomite and limestone layers; and

(2) The upper aquifer which contains dolomite and limestone.

The recharge area of these aquifers is mainly exposed in the western parts of the Judea and Samaria mountains covering an area of about 1800 km^2. Generally, groundwater flows towards west and northwest to the Yarkon and Taninim springs which are the natural outlets of the two aquifers. For the most part, the water wells that tap the aquifer are located on the margins and in the foothills of the high (600–1000 m) Judea–Samaria anticlinorium (Figure 1). In the western foothills of the mountains and further westward, beneath the Coastal Plain, the mountain aquifer beds are uncomfortably overlain and confined by the Mt Scopus group, composed of massive chalk and bituminous chalk of Senonian age and by Early Tertiary (Paleocene) chalk, marl and shales attaining a thickness of 300 m.

Because of the prevailing chalky-shaly composition of the lithological ensemble, the Mt Scopus Group was always regarded as a regional aquiclude overlying the mountain aquifer beds (Blake and Goldschmidt, 1947). The thick sequence of shales of the overlying— mostly Neogene—Saqiye Group and the laterally aligned chalky marl of the Albian Talme Yafe Group, act as impervious barriers along the western boundary of the Yarkon–Taninim aquifer (Avisar et al, 2003).

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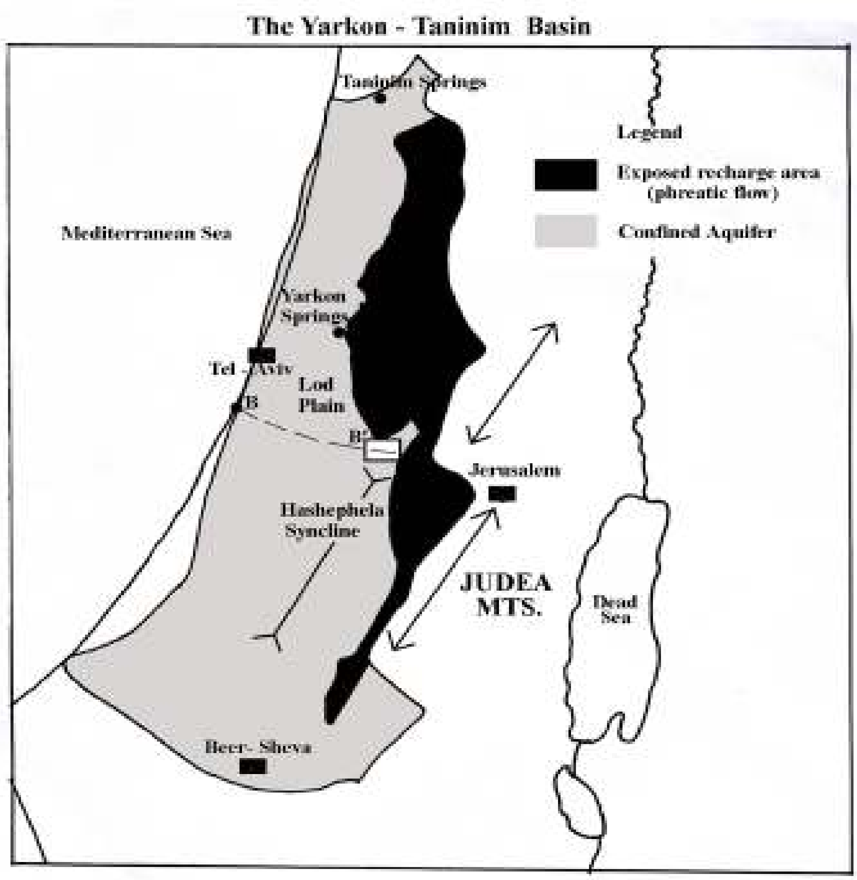

Figure 1: The western part of the Mountain Aquifer- The Yarkon-Taninim Basin.
(Source :*Avisar*)

Environmental Hazards:

The state of Israel and the Palestinian Authority are located in a region with an acute water shortage; the issue of water use and allocation constitutes one of this region's most problems. In order to meet growing demand required by both Israel and Palestinian Authority's urban, agriculture and industrial sectors, Israel is currently fully exploiting its water resources, and in only a few years the underground resources available will be depleted even under conditions of maximum efficiency.

Dependence on precipitation and the seasonal fluctuations of the Sea of Galilee (the Kinneret), in combination with the dire conditions of the coastal aquifer created by pollution from industrial sources, urban sewage, pesticides, effluents from waste disposal sites and others, have put serious limitations on the amount of available quality drinking water. The importance of the mountain aquifer has thus grown as Israeli's main supply of potable water. Moreover, the weakening conditions of other water sources will force Israel in the not too distant future to lean even more heavily on this resource (Avisar. 1996.)

The Yarkon-Taninim basin runs the length of the central mountain range in Israel. The aquifer is structurally complex, with a diverse lithology, many faults, and a dissected anticlinorium. The rock formations in the recharge zone, the region in which precipitations penetrates vertically below ground, is hydrologically varied and has a different level of fragility. This differentiation is the key to understanding the level of impact of the pollutants on the groundwater. In addition this differentiation makes it possible to divide this region into several sub- regions on the basis of their susceptibility to pollution and thereby, to recommend a sustainable plan for this region. Portions of this region are karstic, a characteristic that increases the hydraulic conductivity of those areas and that accounts for a danger of the aquifer's water being polluted heavily and rapidly by sources of human pollution, such as: urban, agricultural and industrial wastewater and leakage from gas stations.

The potential sources of pollution to the mountain aquifer can be found in both Palestinian and Israeli development. Palestinian urban centers have grown in the past several decades in the West bank, and consumption of drinking water has increased, while a sufficient sewage and waste disposal infrastructure remains absent. The steady discharge of municipal from Palestinian towns and cities constitutes a significant pollution source that needs to be addressed.

The most significant regional change, however, may have taken place during the 70's and 80's of the twentieth century, when as a result of political and ideological policy, a large Jewish population began settling above the mountain aquifer. Motivated by political considerations, these new rural and urban settlements were established without sufficient environmental planning or regard for the protection of water resources. These demographic changes did not bring with them technical solutions for the pollution that the new settlements would generate above this aquifer. The resulting discharges have begun to disturb the groundwater's chemical balance.

In general, the major demographic, and consequently environmental changes that threaten the mountain aquifer include: a high birth rate, increasing urbanization and settlement, lack of planning and inspection, creation of industrial areas containing a wide variety of factories, lacking modern wastewater treatment plans (WWTP), unsupervised solid-waste dumps located at the edge of settlements and villages, and deficiencies in sewage infrastructure resulting in raw sewage discharge into river/stream basins. These factors have also contributed to the contamination of the local groundwater and the destruction of natural ecosystems (Avisar, 1996).

Large quantities of untreated sewage run on the surface of the Mountain Aquifer percolate into the ground and threaten the continued utilization of vital water resources. It's undisputed that the pollution sources are both Palestinian and Israeli in origin, and that the constitute a significant threat to future water supply. Evidence shows that groundwater in some locations has already been polluted. The lower deep limestone aquifer is especially prone to contamination due to its karstic nature and the quick transit of pollutants through it. Overexploitation may lead to a rapid rate of saline water infiltration from surrounding saline water sources.

Technical Solutions:

Israelis living inside the nation's 1967 boundaries consume about three times as much water per person for household use as do Palestinians. The real issue over water is not whether the Palestinians will get more water; due to Israeli concessions on water quantity. Implicitly, Israel has already agreed to allow for additional transfers of water beyond the interim agreement, and new desalination plants will make this possible. Rather, the main question is whether both Israel and the Palestinian authority will share management of the water and particularly of the Mountain Aquifer and act to protect this critical resource.

Under decades of Israeli control over the mountainous recharge region, no meaningful steps were taken to develop adequate resources for the preservation of the mountain aquifer. Development in the region was hurried and advanced without sufficient consideration regarding sustainable water management. The planning and building process, driven by short-term political considerations, did not take into account the hydrological fragility of the aquifer.

In particular, the governments never took responsibility for the future of this critical water resource. This neglect is perfectly demonstrated by the chronic lack of solution for the wastewater of Arab villages and Jewish settlements. No government (on either side) allocated effective inspection and enforcement of pollution sources above the most important water resources in the region.

With the recent renewal of the peace process in the Middle East, Israelis and Palestinians have struggled to define the content and nature of an agreement concerning the allocation of the water of the mountain aquifer. It is clear to all that the coming years will be characterized by geopolitical changes. It is important that they strengthen the capacities of the parties involved to maintain this essential source of water.

Taking into account both the physical characteristics of the region and the expected growth in its population, Israel and Palestinians at this stage must seek to better understand the environmental impacts of the rapid demographic changes and the development anticipated to support it. The link between the fates of these two nations and that of the mountain aquifer demands a radical improvement in understanding the relationship between human activities and this critical natural resources- the mountain aquifer.

The Israeli-Palestinian peace process may have been stalled for several years, but scientists from both sides have continued to work, and have made substantial progress in resolving one of the most key hydrological questions. At present, Palestinians and Israelis are moving toward a political resolution of their more than half a century old conflict. The overall mission of a peace agreement regarding the Mountain Aquifer, therefore, should be to reduce or to eliminate groundwater pollution arising from Israeli and Palestinian municipalities/settlements/industries and gas stations. Future collaboration will need to eliminate the myriad sources of groundwater pollution that arise from anthropogenic activity; establish guidelines for monitoring, managing, and reducing sources of groundwater pollution in Israeli and Palestinian municipalities/settlements/villages; strengthen technical know-how and build a network of Israeli and Palestinian water practitioners at the municipal level; and create commitment within Israeli and Palestinian municipalities to improve environmental performance in their jurisdictions.

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Shared Groundwater Resources:
Environmental Hazards and Technical Solutions in Palestine

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Introduction

Transboundary or shared water resources imply hydrological interdependence, connecting different riparian countries within the one-shared system by the use of these waters for their various needs. The borders of groundwater and surface catchments and national boundaries are obviously not congruent, and international law and practices are to be followed to define the right of all riparian states to their water needs in any international water basin.

The water sources in Palestine (e.g. the inland region of the West Bank and the coastal region of the Gaza Strip) are primarily from groundwater wells, the only surface water being from springs and the seasonal flow in wadis during the rainy season. All the water from the Jordan River that runs along Palestine's eastern border is unavailable to Palestinians as it is totally militarily controlled by the Israelis. Thus, the main source of water supply in Palestine for all uses – domestic, agricultural, and industrial – originates as groundwater.

The gap between water demand and water consumption in Palestine has widened since 1948. The population has increased, but the quantity of available freshwater has remained essentially the same. The access to water resources has been constrained and restricted due to the political situation. Throughout the Middle East, there is a gap between water supply and water demand. In Palestine, this gap is growing with time because water supply is artificially constrained by the stagnation of the Peace Process.

This gap is having severe adverse effects on both current and future Palestinian socio-economic development. This chapter considers specific measures that need to be implemented to change the present trends.

Palestinian Groundwater Resources

The existing water resources of Palestine are derived from four aquifer basins (the Western, Eastern, Northeastern, and Coastal) as well as a series of springs that emanate from the groundwater. The Eastern aquifer basin is not considered a shared aquifer.

The Western Groundwater Basin is considered as one unit called the Nahr El-Auja-Tamaseeh (Yarkoun-Taninim in Hebrew) Basin. Water is discharged into the coastal plain. A small portion of the rainwater that seeps through the exposed parts of the Cenomaniam and Turonian aquifers in the Western Aquifer Basin flows in springs draining the sloping aquifers – but most of the water reaches the shared aquifer and it is tapped by wells – especially along the West Bank's 1948 Armistice Line with Israel – with the greater usage being now on the Israeli side. The natural drainage outlets of the western aquifer are two separate spring systems, the Nahr El-Auja (Yarkoun) springs and the Temaseeh (Taninim) springs near Carmel. Most of the aquifer is cut off from contact with the waters of the Mediterranean sea by aquicludes that penetrate to a great depth.

The Northeastern Groundwater Basin is subdivided into two overlying aquifers – both discharging in the valleys of Beisan and Zerein (now called Yizra'el by the Israelis). The two aquifers are: the Cenomanian/Turonian aquifer, and the Eocene aquifer. The natural drainage outlets of West Bank's Cenomanian/Turonian aquifer are for the most part all in Israel, mainly the springs in the Beisan Valley (4 major springs and 20 small springs). The water level in this aquifer is constantly declining, which deteriorates and depletes the West Bank underground water supply. In fact, the Jenin area's many springs have dried out completely – a city that historically was known for its lush landscape due to numerous natural springs.

The Eastern Groundwater Basin drains into the Jordan Valley and includes six almost separate groundwater basins. These aquifer basins are not considered to be shared resources. Israel currently, however, employs several wells, pumping an unknown amount from these strata.

Groundwater is also the only fresh water resource in the coastal region of Palestine, i.e., the Gaza Strip. The aquifer in the Gaza Strip is composed of a number of sub-aquifers made up mainly of sand, sandstone and gravels of the Quaternary Age that are at times separated by impervious and semi-pervious clayey layers. The over-pumping of the coastal aquifer of the Gaza Strip and the resulting increase in salinity in most of the well water of the area is the subject of chapter 12.

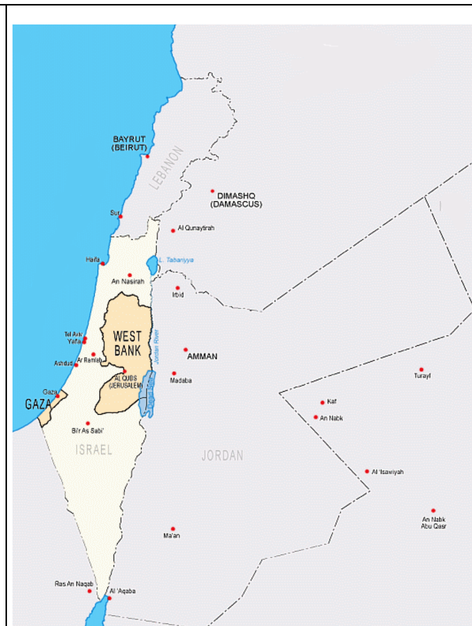
Natural recharge (replenishment) of all the aquifers in the central hilly chain of the West Bank between the Mediterranean Sea and the Jordan River occurs predominantly in the West Bank.

	
Shared and Non-shared Groundwater Aquifers (Kinneret Basin = Tiberias Basin)	Shared and Non-shared Surface Water Catchments (Map also shows network of wadi runoffs.)

PHG, 2004 Aliewi and Assaf, 2006

Figure 1.

There are two surface catchment areas in Palestine: the Western catchment areas that drain to the Mediterranean Sea, and the Eastern catchment areas which drain in to the Jordan River and the Dead Sea Basins. The only permanent source of surface water within the present *boundaries* of Palestine is the Jordan River (Figure 2). The situation there will be presented in chapter 11.



Shared Surface Water Resources The five riparians of the Jordan River Basin Lebanon, Syria, Jordan, Palestine and Israel	The Palestinians are co-riparians in the Jordan River Basin and the Dead Sea Basin.

Aliewi and Assaf, 2006

Figure 2. The Jordan River: source of surface water

Note: Topographically, Egypt is riparian to the Jordan River Basin, however, Egyptian territory does not contribute water to the basin, except for the possibility of intermittent, seasonal wadis.

The source of water supply in Palestine is from rainwater. The level of rainfall varies according to the topography and location. The prevailing rain-bearing winds are westerlies on which the rising ground acts to force the moist air upwards, causing precipitation in the hills of the West Bank inland region. The rainwater which falls in the West Bank flows to the east and west following the natural slopes of the central mountain range. As the western slopes are gentler than the eastern slopes and receive more rainfall, the western groundwater aquifers have a higher natural recharge rate. Rainfall on the eastern slopes, however, feeds the springs along the eastern slopes as well as the deep aquifers that dip toward the Jordan Valley that are tapped by Israeli settlers. In the Gaza Strip coastal area, the rainfall that remains after evapotranspiration infiltrates the sandy soil and recharges the groundwater aquifers.

As can be seen from the above, another transboundary issue is natural water recharge of the aquifer basins, as estimated below:

Basin	Range of Recharge Mcm/yr Inside the West Bank	Recharge Mcm/yr Outside the West Bank
Eastern	125 – 197 Mcm / yr	zero
Northeastern	132 – 177	35
Western	317 – 366	37
Total	574 – 740	72

For example, the recharge area of the unconfined part of the productive Western aquifer inside the West Bank is 68% of the total unconfined aquifer area. The area outside the Green Line is 32% of the unconfined aquifer area, which is mainly a discharge or abstraction area, except in Jerusalem. The area of the confined part of the Western aquifer (light purple in color in the first map) is entirely outside the West Bank and it also is mainly a discharge or abstraction zone (PHG, 2004).

Towards Sustainable Water Management

The dual threats of water insufficiency for basic needs and development, and inequality in the right to use - and the control over - both water resources and water supply constitute a most urgent environmental and human rights crisis for Palestinians. Increasing availability of basic water supply and sanitation also constitutes a cost effective measure for promoting public health.

Intensive use of water, fertilizers, and other agricultural inputs for crop production at present are the major cause of problems in soil and groundwater salinization, nutrient imbalances, and environmental degradation. Add to this the pollutant potential of untreated wastewater and runoff and leakage from solid waste dumps.

The approach to water resources management in this region should evolve together with the social and economic development of the area as the growing demands of water for sectorial use and waste products disposal increase the stress on the available supplies of adequate water quality. Every cubic meter of water deemed unusable due to poor quality, or improper utilization, is in reality a direct loss in the water supply of the region. Deteriorating water quality can reduce available water supplies just as surely as drought. The fact is that the amount of water available for any purpose in any location is a function of the quality of available water supplies.

Groundwater Management

For the sake of thoroughness, the more traditional outline of major management options based on technical solutions for the sustainable development and environmental protection of shared water resources are:

- Groundwater supply development
    - drilling of new production and monitoring wells
    - rehabilitation of existing wells
- Storm water harvesting
    - for irrigation
    - for artificial recharge of groundwater for storage
- Improving water and wastewater infrastructure
    - rehabilitation of water networks and leak detection
    - rehabilitation of spring conveyance systems

  - installation of new water networks, reservoirs and main transmission lines
  - construction of wastewater collection, treatment plants and reuse systems for agriculture

- Importation of water or
- Desalination

The combination of political strife, resource overuse, and continued contamination of water sources means that freshwater scarcity will reach critical levels. The problem, as mentioned, is not only quantity, but also quality. Critical resource threats include pollution of freshwater by industrial activities and untreated human wastes, and contamination of wadis and aquifers due to runoff from fertilizers, pesticides and wastewater. The immediate task facing Palestinian water managers is to solve actual problems that have occurred, or will occur, in specific areas within countries. This will require coordination with their Israeli counterparts.

The ever-dwindling supply of freshwater (both in quantity and in quality) – and the irrevocability of inappropriate policy measures by *some* – requires regionally unified, and internationally supported, definitive, and ecologically sound changes to current policies and practices to insure an adequate future water supply for all peoples in the region.

Frameworks for Cooperative Groundwater Management

Water resource management encompasses assessment of all available water resources and water resource utilization in all its forms, as well as water protection and conservation methods. Water management - especially in this semi-arid area - essentially means the formulation and implementation of a sustainable socio-economic development policy with corresponding regulations and guidelines. These management areas can be conceptualized or divided into three components - water supply, water utilization and water discharge. Palestinian and Israeli joint water management decisions should address the concept of water resources in all three phases in what can be called the *"water usage cycle"* which should be visualized from the very beginning of any planning phase as non-separable elements of a process.

Water Supply Component Allocation of Water Resources	Referring to water extraction, regulation, distribution and maintenance techniques that aim toward an efficient and integrated management of water sources.
Water Utilization Component Demand management: domestic, industrial and agricultural use.	Referring to the sectorial uses of water, seeking more efficient production processes that minimize water requirements. Emphasizing the efficient use of water by all end-users and the need to minimize water use per unit of end product.
Water Discharge Component Pollution control of water resources.	Referring to a controlled management of waste disposal in order to avoid pollution and to combat environmental and health hazards due to deteriorating water quality before and after use.

The pollution from non-point sources may be the most significant cause of water contamination. It must be remembered that groundwater is susceptible to contamination not only from current discharges, but also from those that occurred even many decades ago. Fertilizer residues, toxic chemicals and other materials discharged onto the soil can pose a serious hazard to groundwater for many years.

The Palestinians have a finite supply of drinking water – under pressure from population growth – but also by the demands placed on it by so-called progress. Many of the products of modern civilization that are dumped in the groundwater supplies are proving to be surprisingly persistent. The compounds ending up in the water supply (and wastewater effluent) are playing an increasingly important role in the life cycle of all creatures. Chemicals being poured into the water supplies are likely to interact, exposing humans and animals to unpredictable additive and synergistic effects.

Water supply in the mountain aquifer is by definition finite. The mechanisms to manage water scarcity (whether due to climate change or due to outside constraints) must include conservation and demand management, along with education programs, and strategies for addressing water quality. Economic utilization, protection and conservation of water should constitute the fundamental goals of every measure or action undertaken in pursuit of a rational management of water resources. Issues must be addressed that relate to water utilization techniques in the framework of minimizing the negative secondary effects during all phases of water supply, - i.e., distribution, utilization and disposal – i.e., *"the water usage cycle"*. These water management goals should include a set of techniques, structural measures and related policies required to achieve an efficient allocation, distribution, operation and utilization of water resources, as well as adequate environmental, agricultural, health and pollution control.

The following objectives should constitute the basis for the rational protection and development of Palestinian water resources:

- assessment of water resources availability,
- assessment of all the possible uses of water resources,
- development of managerial activities dealing with both administrative and non-structural measures,
- initiation of water protection and conservation techniques, and
- review of agricultural practices and policies.

A Comprehensive Strategy for Sustainable Development and Environmental Protection of Shared Water Resources

Fluctuations in annual precipitation patterns and the unpredictability of aquifer recharge are likely to grow worse for the foreseeable future due to climate change. A strategy of adaptation to periodic or increasing drought conditions in the region as a whole must be assembled and implemented. The strategy needs to be based on technical solutions whose basic elements include:

- The Reuse of Regional Water(s)
    - Reuse of treated wastewater
    - Reuse of collected and treated stormwater and urban runoff
    - Small to large-scale rainwater harvesting schemes
    - Small to large-scale artificial recharge schemes

- Adaptive agricultural practices – changing cropping patterns
    - Pilot projects for the development of economic industrial crops in the agricultural sector, e.g., jojoba, aloe vera, and bio-fuels
    - Pilot projects for trees and ground-covers to combat desertification
    - Promotion of rain-fed and draught resistant trees and crops to farmers
    - Promotion of both public and individual interest in environmentally needed greenery for the region, i.e., plant a tree, fence your land with trees, etc.
    - Lining irrigation canals, reusing drainage water, improving the efficiency of irrigation practices

- The maintenance and development of water resources in wadis
    - Utilization of intermittent wadi flows
    - Development, preservation and utilization of small springs
    - Land use studies, including the return of the practice of extensive land terracing for the beneficial use of available rainfall

- The storage and distribution of scarce waters[39]
    - Studies of different types of small to large-scale reservoirs and pools
    - Leak detection surveys – and maintenance programs
    - Household water tank surveys – and water quality testing

- Artificial recharge of groundwater and aquifer storage and recovery

- Saving of water in the household
  - Promotion and pilot projects to illustrate the positive effect of utilizing water-saving and efficient household fittings
  - Demonstration projects showing how dual piping (fresh and grey waters) works in a normal household

- Promoting both public and private participation (i.e., community development) in water, sanitation, and environmental projects

Infrastructure: More specifically, the future management strategy for shared groundwater resources needs to ensure development of infrastructure schemes in order to utilize the runoff flow in the wadis of the Eastern Aquifer which is the Palestinian side of the Jordan River Valley on the basis of a comprehensive technical and socio-economical analysis of the major wadis. This should include construction of storage dams or water retention structures on main wadis of the Western Bank of the Lower Jordan River Valley, Palestine. There is also a need for geological studies, rehabilitation and development of major springs, including civil works and storage reservoirs based on seismic and geophysical surveys for geological and water resource assessment studies

Feasibility and technical studies should be made with an eye to artificial recharge of aquifers from seasonal wadi runoff, urban runoff, or treated wastewater for either seasonal storage or as a barrier for salt-water intrusion. These should involve feasibility and technical studies and implementation of the use of winter runoff waters collected in flood plain areas, such as Marj Sanour of Jenin District

Expanded Recharge: There is also a need to supplement natural rates of recharge through artificial recharge. Artificial recharge can be accomplished either indirectly by percolating water through the soil profile of percolation basins, or by injecting water directly into the aquifer. The possibilities for artificial groundwater recharge also open the prospect of groundwater storage or groundwater banking. This should begin with the implementation of pilot projects for artificial recharge and aquifer storage along with recovery and utilization of excess surface flows or treated wastewater. This requires hydrological and meteorological monitoring networks, including gauging, monitoring and sampling systems with all necessary equipment and vehicles (for water and soil monitoring). Pilot projects for the use of renewable energy (solar and wind) for water extraction and/or distribution shold be considered.

Research and pilot studies for the use of brackish water in agriculture and industry – and brackish water desalination using renewable energy.

Demand: A comprehensive strategy needs to include measures that can manage water demand. In-depth studies of existing cropping patterns with a recommendation for a change in policy towards economic rainfed cropping (or with supplemental irrigation) in the entire Jordan River Basin area[40] should be undertaken. For example,almonds, olives (with quality grading specifications), herbs and spices, barley, vetch and maize/sorghum (not corn), and jojoba are all promising. And the feasibility of brackish water use should be better characterized on crops such as industrial tomatoes and melons (cantaloupes), for example.

Regulation: Permit systems need to be enforced for point source industrial discharges, including the requirement to use the best available technology to treat wastewater prior to discharge into a sewerage system. Firms need to be encouraged to recycle and reuse both process and cooling waters. Quotas and/or pumping taxes are the usual tools recommended for the regulation of groundwater extraction.

[40] The number of irrigable donums in the Lower Jordan River Valley – Palestinian Side – is 200,000. Currently, 71,898 donums are irrigated (when possible).

Utilization of wastewater: Wastewater reuse provides a drought-proof resource for a community that automatically increases as population growth increases. Technologies for wastewater collection are:

- greywater separation as an alternative management scheme for individual households
- alternatives to conventional gravity sewerage which are applicable to small communities
- transporting wastewater to decentralized treatment plants.

A Water Resources Protection and Development Program for the sustainable development and environmental protection of shared water resources should also include sectors for Public Awareness (Dissemination of Information) and Capacity Building programs.

Recommendations:

Meeting the sustainability challenge for water resources development will require an advanced level of regional management. The regional water resources management structure (institutions and organizations) must manage two systems:

- the natural water resources system (existing water, and floods and droughts); and
- the human activity system (water demands and pollution).

Regional Management must be:

- multi-purpose addressing:
  domestic water supply, irrigation, industry, and the needs of nature;
- have multiple objectives ensuring:
  economic productivity, environmental quality, social equity, and human health.
- through the use of multiple means of:
  physical structures, regulations, dissemination of information, and economic incentives.

What is needed is to move away from the technical-fix dominated and largely supply-oriented management structure of water resource management. The focus has to be extended from ‘blue water’ to incorporate also ‘green water’ issues, and from water quantity to incorporate water quality as well. An integrated approach is necessary for environmental management and water management. Planning should incorporate a multi-sectoral framework. All sorts of interdependency linkages and implementation barriers need to be addressed in an overarching and integrated manner. The conventional set up of sectoral water management institutions is not able to cope with the present water problems facing the area. The solutions to these problems require an integrated approach to water, land use, and ecosystems, addressing the role of water within the context of social and economic development and environmental sustainability.

Problems that are facing water resources management in the area can be summarized as an increase in demand and waste production due to population growth and socioeconomic development, decrease in the availability of water per capita, high losses of urban water, and the increasing depletion and pollution of groundwater.

Water is the driving force of sustainable development. Thus, rational water management in this region should be founded upon a thorough understanding of all the types of water available and its movement. A major objective should be to view hydrological processes in relationship with the environment *as well as human activities*, emphasizing the multi-purpose utilization and conservation of water resources to meet the needs of economic and social development throughout the area.

Proper management of Palestinian water resources requires consideration of both supply and demand. Naturally occurring water resources in Palestine and the demand for their usage is currently a critical political, economic and technical issue. Palestinian water usage, management, protection and conservation constitute a top priority strategic package that must be freely developed. With ever-declining safe and sufficient water sources, it is imperative that Palestinians manage their most valuable natural resource -

water - if a continued reliable and sustainable water supply is to be expected in the future. The fact is that water problems in Palestine are caused not so much by a shortage of fresh water as by its uneven distribution due to practices during the occupation. Applying more science and technology, rather than bureaucracy, can help mitigate some of the effects of people's indifference to and abuse of the limited water resources in the area.

Water availability is essential to Palestinian socio-economic development and food security. The agriculture component of the Palestinian economy is the largest user of water and takes the "lion's share" of total water utilized in Palestine, in both the West Bank and Gaza Strip. This fact is also true for Israel and Jordan.

The ongoing rapid growth of the Palestinian population, together with the desired extension of irrigated agriculture and industrial development, are sure to stress the quantity and quality aspects of the natural system of water resources in Palestine because of the limited water resources and the increasing problems associated with the expected imposed limitations.

Emphasis should be on proper water utilization and water conservation - stressing water demand management, rainwater harvesting, dry-farming of rainfed crops, methods and techniques of using refined sewage waters, irrigation with brackish water, desalinization, etc. It should be recognized that there exist varying cultural traditions (e.g., urban versus rural), social structures and degrees of economic development or scientific and physical infrastructure and these differences - even within the small area of Palestine - can affect the choice, use and sustainability of different water resource options.

The development of Palestinian water resources has as its aim - in common with Palestinian development generally - the enhancement of the conditions of human life and must be recognized as an integral part of the social and economic programs. It must always be remembered that development goals are not realizable in the absence of water adequate in quantity and quality.

To date, supply-oriented and resource-oriented water management dominated the scene in Palestine with emphasis on structural measures to cope with supply of water and water-related services. Since the establishment of the Palestinian Water Authority, intensive and extensive institutional development programs have been initiated, aimed at developing the management tools necessary for a sound and sustainable integrated water management policy.

In summary, both the supply and demand management stages of water resource development will have to run concurrently in order that the concept of water supply will not exclude the processes of collection, cleansing and discharge of wastewater which must be directed and seen as being under the same planning umbrella as water resources development (the water usage cycle).

Intensifying water scarcity (whether due to climate change or due to outside constraints) will remain a dominating feature in the Palestinian/Israeli water scene for the foreseeable future. Water scarcity will be managed by a variety of techniques including augmentation of supplies, pricing, education, water saving technologies, and water recycling. Limited water supplies need to be stretched and protected in order to serve the growing demands for additional water from almost every water-using sector.

What is spoken of as a water problem in the area is not solely a hydrological problem, but a societal problem. The main task is to master the political forces, to build up the balancing forces, and to develop competent management systems. Water is the source of life and a natural resource that sustains the environment and supports livelihoods – but it is also a source of risk and vulnerability. From the beginning to the end, it is poverty, power, and inequality that are the roots of the water scarcity problem in the region.

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Editors' Summary

The crux of the historic disagreement between Palestinian and Israeli negotiators in the water realm has involved rights to the mountain aquifer. Both sides have conveniently adopted theoretical positions which support their hydrological interests: Hence Israel argues that it enjoys historic rights to the aquifer, pointing to the storage capacity and established wells inside Israel's 1967 borders. Palestinians maintain their rights as riparians, relying on the location of the aquifer recharge area, where the rainfall actually originated. Resolving this "zero-sum-game" dynamic through other formulations – such as "equitable use" or the "needs" of the parties has only been moderately successful. Ultimately, as was the case in the Israeli-Jordanian peace accord, a political compromise must be made, which should be far easier today given the availability of alternative desalinated sources for both sides. Yet, taking concrete measures to protect the aquifer can not wait for such diplomatic resolution.

There is a sense that while politicians have naturally focused on the "allocation" debate which is easy to grasp, the more complex dynamics of joint management and the associated technical challenges for sustainable management of the mountain aquifer have not received adequate attention. As a result, the sources of contamination have not been abated. In particular, municipal sewage and non point source pollution involving runoff from agriculture and from urban sources have not been addressed. The importance of the many projects and practices for protecting the Mountain Aquifer that are detailed in this chapter is not disputed by technical experts on either side.

Regardless of ultimate water allocation, there needs to be a coordinated system of management and regulation between the two parties that is overseen by technical experts. These experts need to be freed to the extent possible from political constraints and take the necessary measures to ensure future sustainable, high-quality yields of groundwater. Continued neglect of pollution prevention technologies, infrastructures and oversight could lead to a shared resource which is of little value. The grave situation of the coastal aquifer underlying the Gaza Strp is a sobering reminder that hydrological systems will not wait for political harmony, but are easily compromised given the relentless flow of contaminants and uncontrolled tendencies towards extraction beyond sustainable levels.

Upgrading sewage systems in the recharge area remains the single greatest imperative for protecting the mountain aquifer. Over the past years a litany of sanitary projects have been discontinued in the West Bank and Gaza due to the political instability. Ironically, funds were available from international aid agencies for treating most of the sewage from Palestinian cities. Already, fecal contamination can be measured in many of the West Bank streams, portending water quality problems in the underlying aquifer. An immediate, "emergency" initiative to collect and treat all untreated sewage in the Palestinian sector and shift the existing cesspool systems to connect to these centralized facilities must be initiated immediately,

Even after allocations find a political resolution, water quantity will continue to be an open problem that must be addressed dispassionately and creatively. The effects of the anticipated climate change on aquifer recharge have been sufficiently considered. If projections of the models endorsed by the United Nations International Panel on Climate Change (IPCC) are correct, recharge will be diminished. Indeed, it has been argued that the allocation schemes that emerged from the interim Oslo agreement in the mid-1990s relied on the rainfall levels of the preceding years, which was a relatively wet period. Hence, many wells have essentially been mining groundwater resources. The present drawdown on the aquifer due to continuous pumping will probably grow worse due to effects of global warming, and the hydrological damage could be irreversible.

In the past, agriculture served in Israel as a buffer for drought periods. But, with the shift to wastewater, impact of cuts to agriculture will be far more painful – with orchards and mature trees being sacrificed rather than a single year's annual yields, for which compensation can be provided. Preparing for such droughts should be done in a coordinated fashion. Desalination offers protection against these fluctuations.

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6. Stream Restoration

While the term "river" is a misnomer in water scarce areas, the many natural streams of the area are in chronically poor condition. Beyond sewage treatment, industrial wastes, nonpoint source discharges and a host of other pollution sources need to be treated. These two chapters – written by a Palestinian sanitary wastes expert and environmental expert and Israeli ecologists suggests that there is room for cooperation in the area of stream restoration and that a final agreement can play a key role in facilitating this.

The Condition of Streams and Prospects for Restoration in Palestine

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Stream Contamination: A Transboundary Problem

While a rich variety of streams flow through the Palestinian Authority, most of them are highly polluted, mainly from untreated waste water and other polluting activities. The pollutants not only flow in the surface water, but often infiltrate the groundwater which both parties use for drinking and for other purposes. The present condition of the streams is exacerbated by the geopolitical context. Many streams in the PA are transboundary, and do not recognize political borders. The end result is that contaminated waters flow across the border in both directions causing pollution and degradation of water quality. As a result, both sides suffer. Because so much of the problem is transboundary in nature, it is would be impossible to repair these problems without Israelis and Palestinians cooperating. Without working together stream restoration turns into a 'lose-lose' situation.

Israelis frequently focus on streams that flow west -- from the West Bank towards the Mediterranean Sea with Palestinian pollution reaching Israel. But there are numerous examples of streams that flow east: from Israel to Palestine. These include the Kidron valley whose flow begins in the neighbourhoods of West Jerusalem, continues through East Jerusalem and moves on to the Bethlehem area and out into the Dead Sea. At present this sewage in the stream bed is raw without any systematic treatment, although there is some natural decomposition of contaminants that takes place during the flow. Little I anything has been done thus far by Israel to prevent the raw sewage from flowing. The same situation can be seen in the Jordan river which is polluted by waste water from the Beit She'an region below the Degania dam. Untreated waste water also flows into the Jordan in the Wadi Qelt catchment area around Jericho when there are heavy storms and floods.

Examples of streams that flow east from Palestine to Israel include the Zomar-Alexander catchment that flows from Nablus through Tulkarem and into Emek Hefer and down the Mediterranean. The Besor, the largest watershed in the region, flows through three political entities from Hebron to Beersheva and then into the Gaza Strip and eventually to the Mediterranean. In short, rather than pointing fingers about who bears a greater responsibility for past contamination, it is time to begin to work together to address these significant environmental challenges.

The Importance of Clean Streams in Palestinian Culture

In Islam, water is life and everything was created from water. In fact, this is no different from the way water is perceived in many cultures around the world. Since Palestinians know how vital water is to life, despite the difficulties we face, citizens and the government to make a substantial effort to prevent pollution from waste water.

Local streams have particular religious significance for Christian Palestinians as they do for Christians around the world, especially the baptism site on the river Jordan. It is the dream of every Christian to visit this site and to be baptised in the Jordan. Unfortunately, the water at the baptism site is not in sufficiently good condition to serve this traditional function. Despite the pollution, in many places, you will still find people trying to enjoy the water and the beauty of nature.

Palestinians are an agricultural people. The presence of freshwater streams has resulted in a variety of agricultural practices that make optimal use of the flow. However, since so many of the streams have become heavily polluted with sewage, for many years, farmers were basically using sewage water to grow crops, including salad vegetables. Given the groundwater depth in the West Bank, there is limited access to groundwater for irrigating crops. For many Palestinians to remain farmers, they had no choice but to use the polluted surface water.

With produce moved from north to south and of course, east to west across the borders to Jordan and into Israel, consumers are often unaware that the fruits and vegetables they are purchasing frequently were grown with sewage water. It can be assumed that they would have been highly reluctant to purchase the vegetables if they knew. The Palestinian Authority has begun to address this problem and irrigation with raw sewage has largely been phased out. However, in Area C, the region controlled by Israeli authorities, such dangerous practices can still be found.

Ground versus Surface Water

There has been joint research and policy analysis conducted between Palestinians and Israelis about the Mountain aquifer for many years. Considerable monitoring, evaluation and discussions ensued about how this resource could be jointly managed, with allocations of quantities for each party recommended and scenarios about responding to problems considered. There has been far less joint research and discussion about surface water. Limited attention has been focused on questions such as how to improve the flow of the springs and streams; how to protect the streams in summer; and how to promote wastewater systems and decentralised sewage treatment plants for small communities.

Accordingly, Palestinian experts have traditionally focused their hydrological research and expertise in the area of ground water, rather than surface water. Yet, the effects caused by polluted surface water are surely as serious: local people suffer from raw sewage flowing besides their home which can leave severe health impacts, as well as from the acute nuisances associated with the constant smell and the mosquitoes. However, at the official level, priority has been given to ensuring the supply of drinking water from the Mountain aquifer. After the Oslo interim peace accord, international donors also prioritised freshwater drinking supply, without giving parallel support to wastewater infrastructure development. These issues are, however, clearly linked. If raw sewage is flowing on the surface, it is easy for it to percolate into the Mountain aquifer and cause pollution. The karst/limestone aquifers allow wastewater to penetrate very easily and the end result could be catastrophic for drinking water supply. As such, it is essential to consider the two issues in parallel.

Pollution Sources

Sewage wastewater is undoubtedly the major source of pollutants in Palestinian surface water resources. Most urban areas in the West Bank have little or no sewage treatment, discharging the effluents in a raw form.. The associated organic loadings and bacterial contamination leave their mark on the streams, their ecosystems and the underlying groundwater. The odor and mosquito nuisance created can become unbearable.

There are in fact a variety of other contaminants that must be addressed as part of a stream restoration strategy. For example, there is also considerable leachate which derives from inappropriate management of solid waste. In practice, safe disposal of solid waste can only be found in the northern sections of the West Bank where the first modern landfill sites were built. In the center and the south of the West Bank, rubbish is simply dumped and leachate easily flows, with rainwater reaching nearby creeks and streams during the rainy season. The leachate can of course infiltrate the groundwater as well.

Industrial wastes also constitute a source of pollution, although a less significant one in Palestine than in Israel, due to the absence of heavy industry. For example, wastewater from the dye industry and from slaughterhouses is typically discharged into rivers and streams without treatment. As mentioned, there is also a steady flow of industrial waste from the Israeli settlements into Palestinian streams without treatment, sometimes it is even hazardous waste. A good example is the Barkan Industrial Region, located near the city of Ariel in the north of the West Bank. Israeli regulations on wastewater treatment are not strictly enforced there. Since the 1970's many industries have relocated there, presumably to take advantage of the lenient environmental enforcement and tax incentives for settling in the Wet Bank. In some cases, such as the leather tanning industry – a substantial portion of a heavily polluting industry appears to have coordinated their geographical migration.

As a result, Palestine's streams receive effluents from a myriad of industrial sources: from small-scale electroplating industries to car repair garages. Regardless of the location, the contaminants eventually find their way into the streams. The potential health risk is not well characterized but surely is ever present. The problem is not only one of technology and enforcement, but also economic. Pollution prevention requires a good economy so that businesses can start paying for these services rather than dumping their waste because they cannot afford to pay for treatment.

Wastewater from olive mills is also a major pollutant in Palestinian streams. Palestine is famous for its olive production. Despite the short picking season, the consequences of the wastewater from olive oil residuals flowing into streams are very severe. Olive water has a high load of organic pollutants and increases the salinity of a stream. In a recent research initiative, it was found that during the olive production season, Israelis actually stopped using the water that flows into their part of the catchment because of high salinity. The consequences of the olive oil production on the ecosystem of stream river on the Israeli side during the olive season can also clearly be seen. The impact was especially prevalent in those areas where the stream had been restored, with massive damage to aquatic life and significant fish kills due to organic loadings and oxygen depletion. The unfortunate impacts highlight the imperative of cooperation, without which there will be ecological suffering.

These environmental hazards can be addressed. Recently, as part of an Palestinian-Israeli research initiative assessing the conditions in the Zomar – Alexander stream the full impact of the olive oil discharges were quantified. As a result, for the first time last year, with support from an outside company, the Palestine Water and Environmental Development Organization helped arrange for the wastes to be collected from the Palestinian olive mills and transported to special treatment plants in Israel so that they would not be dumped in the stream.

Ephemeral versus permanent flow dilemma?

The fact that wastewater now flows more or less continuously in their streams presents Palestinians with a dilemma. It is clear that capturing and treating the wastewater that flows in the wadis is important, since the present pollution damages the eco-system and threatens ground and surface water integrity. However, if wastewater is not flowing, the volume of water in the wadis will drop precipitously, especially during the summer time. This could also leave the eco-systems which have emerged there much poorer.

It is important to find a way to ensure that good quality water flows in the rivers and that people can enjoy the value of restored areas. Small segments of the Alexander river have already been restored in Israel and serve as a wonderful recreational resource for the general public. Here too, the flow during the dry season is almost entirely based on treated effluents. Palestinians can use examples like this to demonstrate to the public how we can improve a section of river and make it much more attractive, providing recreational benefits for everyone especially the public, who otherwise would not have access to water resources.

Towards Restoration

The first step in cleaning up Palestine's streams requires the prevention of further pollution from point sources. This will require significant investment in regional wastewater collection and treatment systems. Once the contamination ceases, it will be possible to consider repairing and restoring these streams.

If we are to collect, treat and reuse wastewater, Palestinians can learn from Israel with regards to how it might effectively treat it for re-use. Israel has a great deal of experience and is a world-wide leader in the field. Israel could, and should provide training about the technical aspects of treating the water as well as guidance with regards to the implementation of the associated agricultural and irrigation practices. The Palestinians can benefit from the Israeli experience and use it to show Palestinian farmers the benefits of reusing treated wastewater. Should treated waste water become a valuable commodity, it will be possible to demonstrate to Palestinian industry the benefits of paying for wastewater treatment.

The costs of fully treating and reusing waste water may well reach hundreds of millions of dollars on the national scale. It is important that policy makers recognize that the move towards tertiary treatment is not a luxury. From the perspective of water management, there is no other alternative. The only directly available source of potable water available in the West Bank is the groundwater. If wastewater is not collected and treated, the aquifer will be destroyed. While gathering the necessary financial resources is a charge, the longer we wait, the greater the degradation and suffering will be.

Bi-lateral Cooperation in Research

Recently, a three-year research initiative between the Arava Institute for Environmental Studies and the Palestine Water and Environmental Development Organization was completed. It was funded by U.S. AID's Middle East Research and Cooperation program. This was the first comprehensive study that focused on transboundary surface water rather than ground water in Palestine. It highlighted the level of ecological destruction that is happening in many of the catchment areas, and what will need to be achieved in both Israel and Palestine to restore the catchment areas. Despite the critical data that the project generated, it did not succeed in generating additional funds so that it might continue or expand to other transboundary watersheds.

One of the major outcomes of the study was capacity building for Palestinians. Students received masters degrees and research teams were sent to the United States to receive training about preparation and implementation of hydrological models for water management and stream restoration. Palestinian experts gained important experience in working with these models, and equipment for the first time became available for monitoring surface water flow and quality. These can be utilized in other surface water projects with the now-experienced graduates and engineers who are better able to contribute in these fields. No less important is the practical experience gained. The Palestinian team had to learn to work in severe weather conditions – floods and snow – to make sure that the equipment was operating so that data could be collected.

Another valuable benefit of the project was the provision of technical support, for the first time, between Israelis and Palestinians. The research offered an excellent opportunity for Palestinians to learn from Israeli experience as the Israelis have done much more advanced research in the field of stream monitoring and have well equipped laboratories to this end. They have also developed a relatively broad infrastructure and network for regular monitoring.

Many misunderstandings between the two sides were clarified as a result of the project. It also offered a rare opportunity to present the outcomes and associated recommendations to official decision makers on both Israeli and Palestinian sides.
The project suffered, however, due to its inability to access streams in the Gaza region. As one of the watersheds examined was the Hebron – Besor basin, which eventually flows to the Mediterranean via the Gaza Strip, it was unfortunate, that this section of the water shed could not be monitored.

Despite initial discussions, the Palestinian Water Authority (PWA) did not participate officially in the research project. This was largely due to the political dynamics of that period. While it was certainly interested, especially given the clear institutional interests in developing its laboratories, the political situation at that time meant that the PWA could not be a partner. In retrospect, this was valuable for the Palestinian research team which developed in-house expertise. Results of the project were disseminated to all relevant parties – governmental and non-governmental. Yet, in the future, the monitoring of streams and rivers needs to be done by national authorities on a larger scale.

The Good Water Neighbours Project and other Cooperative Stream Initiatives

Beyond research, there have emerged public interest, action and educational oriented programs that have addressed the problem of stream water quality. *Friends of the Earth Middle East*, a regional environmental NGO, with Jordanian, Palestinian and

Israeli offices has for several years been engaged in a public awareness and protection initiative called: the Good Water Neighbours project. The project focuses on cross border co-operation on environment and water between neighbouring communities. Due to its activities, Palestinians and Israelis have been able to consider water conservation techniques such as recycling grey-water, as well as building small scale treatment plants such as wetlands. The project also work in schools on initiatives such as reusing water to flush toilets and for irrigation, as well as learning how to conserve water and to harvest rainwater. *Friends of the Earth Middle East* works with the community to look at the impacts of community water usage and organization on the local stream flow and quality as well as the aquifer recharge. The project also actively promotes organic agriculture.

One of the perceived obstacles to Palestinian efforts to reduce contamination of streams involves capacity and technology. Small dispersed communities, with little funds and no highly trained personnel are not considered as capable of stopping waste water flow. The Good Water Neighbors project shows that small communities can easily handle their wastewater with small scale and low cost technologies. The biggest problem faced by the GWN project involves a chronic lack of financial resources. This meant that only pilot initiatives, workshops and demonstrations could be pursued, and that more meaningful interventions involving, nationwide fully operational projects was not possible. In short, the GWN project could and should be much bigger. Other communities are asking to join. On the Palestinian side, it enjoys the full support of the Palestinian Authority and seeks to include as many communities as possible. Working with small communities has helped to highlight their problems among decision-makers and donors, using methods such as petitions. These methods have helped keep some donors committed.

A good case about the potential of cooperation on surface water is the discussions that emerged about how to coordinate joint sewage treatment plants between cotinuous communities. For example, between Emek Hefer and Tulkarm (in Zomar- Alexander catchment) such facilities have been established as well as between Baqa Shartiya and Baqa el- Garbiya. The project showed that all communities involved are willing to work jointly, and the national authorities are also willing to provide encouragement to such grassroots efforts. Due to the catalyst of civil society, mayors on both sides to discuss in more details how to proceed to ensure that water reaching streams is of higher quality. Such cooperation often catch the attention and support of donors

Indeed transboundary projects that attempt to improve stream quality tend to be 'win-win' projects – in which all sides benefits as due water resources. At the end of the day, the reality of transboundary water dynamics is either a win-win or a loose-loose proposition. Residents of all communities want to get rid of the raw sewage flowing by their homes and to stop the associated smells and the mosquitoes that the sewage bring. Everyone wants a healthy environment and cleaner streams.

Palestinians were often surprise to find that the Israeli authorities are also very supportive. Projects that lead to concrete activities to improve the biological integrity of streams and to abate pollutants not only provide real support for the peace process but also for the future sustainability of these communities. They can bridge the gap between the two peoples. Both sides soon learn that it is in their interest to work together a) so the projects don't collapse and b) to protect their shared water resources.

A Research Agenda for the Future

The MERC research initiative showed the potential of Palestinian and Israeli experts to work together in a joint scientific framework. But the results also pointed to numerous areas where further investigation is necessary.

To begin with, more research on organic loads in transboundary catchments is required, as well as additional chemical and biological analysis. Among the essential questions is the link between surface and ground water issues and the implications for future drinking water quality. More information needs to be collected about surrounding land use patterns and public health related issues. It would help to establish permanent stations in the wadis for testing, especially weather stations, because there was not enough weather data generated in the Palestinian sector.

The project also revealed the extent of progress in surface water monitoring and modelling that has taken place during the past ten years. In particular, building an HSPF model that can offer water managers for both sides the ability to make informed decisions about optimizing control efforts is an important task. Ultimately, the political situation has improved, allowing for the involvement of more international partners and greater involvement by research agencies. Moreoever, Gaza needs to be integrated in future hydrological monitoring research. Beyond surface and ground water, such efforts could provide important information about the future prospects for Mediterranean marine water quality.

Future Stream Function and Designation

In the future, Palestinians seek to treat the wastewater so that it does not pollute streams and restore them for ecological and recreational use. Each Palestinian region should be the site of a high level wastewater treatment facility, allowing for economies of scale and reuse by agriculture. At present, Palestinians lack the financial resources to construct this critical infrastructure.

Agriculture will of course continue, but irrigation will be based on recycled effluents treated to a high standard rather than freshwater. This is because the supply of available freshwater are becoming more and more depleted, while at the same time, the supply of recycled wastewater will grow. A program will need to be established that works with consumers and farmers. Farmers will need to learn which crops can be safely grown in the treated wastewater and how to protect the soil from being salinized. At the same time, consumers must be willing to accept that crops grown using high quality, recycled wastewater are perfectly healthy to eat. The quality of the water must be constantly monitored in order to re-assure the consumer that it is safe. The final water utilization will ultimately be driven by the types of crops grown, with Palestinian agriculture certain to retain some plants that will require fresh water. This strategy should leave reasonable amounts of water available for stream in the Palestinian state.

Palestinian awareness like its infrastructure remains inadequate to address the waste water treatment and stream restoration challenge. Much of the problem involves economic capacity, because Palestine is not a first world country like Israel. It would be well for Israel to consider funding even a single project inside Palestine aimed at improving the waste water quality and improving the biological integrity of transboundary streams. Such an investment would clearly be of benefit to both sides and would certainly benefit Israel, as it is the major user of the groundwater which continues to flow from Palestine into its borders. Given its present economic capabilities, there is no reason why Israel should not begin to act like one of the donor countries from Europe.

Stream restoration under conditions of water scarcity: Insight from the Israeli experience

Stream restoration under conditions of water scarcity: Insight from the Israeli experience

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Introduction

Prior to the establishment of the state of Israel (1948) many of the coastal streams had significant perennial flowing water habitats. Today, two-thirds of the population, a majority of the industry and a considerable share of intensive agriculture activities are located in the coastal plain. Population increase and the ensuing agricultural and urban development resulted in augmented demand for water. For many years water has been diverted for human use (mostly agriculture) directly from the streams or indirectly from the aquifers. Stream channels lost dilution capacity and some dried out. The demographic growth was also followed by increasing production of wastewater that ended up in the streams. Presently many of Israel's streams only flow because of the discharge of effluent.

Since the early 1990s' stream rehabilitation measures and recovery of the stream's environmental and social functions have taken an increasingly important place on the public agenda in Israel. The nature of the attempts to restore streams in Israel where water resources are fully exploited is fundamentally different from efforts conducted in relatively water-rich countries due to the severe competition by different sectors for the limited resource. Presently, reclaimed waste water is the only alternative water source for replenishing water abstracted from the streams. Moreover, most of the watersheds are shared with neighbouring countries which for geopolitical reasons there is virtually no cooperation of watershed management. This worsens the environmental effects and compounds the problems that need to be solved. The situation is further aggravated by relatively low priority given to solving environmental problems in Israel and its neighbouring countries; administrative complexity in Israel emanating from the fact that at least 5 governmental ministries (Interior, Health, Agriculture, Notational Infrastructure, Environmental Protection) have jurisdiction over applicable aspects of the water law negate effective enforcement; not the least, severe financial constraint of relevant governmental ministries holds back implantation of rehabilitation projects. Consequently, in the beginning of the second millennium most of the streams in Israel and its neighbouring countries are still severely impacted anthropogenically.

In this chapter we selectively discuss issues of the attributes and current state of streams in Israel, elucidate on recently studied transboundary polluted streams, and present principles for stream rehabilitation under condition of fully exploited water resources.

Climate setting, geomorphology and geographic variation

Fluvial systems (streams and rivers) are shaped by climate, geomorphology and human activities. Israel is situated at the eastern part of the Mediterranean Sea (29^o – 33^oN / 34^o – 35^oE) and is governed by a Mediterranean-climate, distinguished by relatively hot and dry summers (June-September) followed by mild and wet winters (December-April). The precipitation regime is characterized by high seasonal predictability combined with high inter-annual variability (low constancy). Annual rainfall in Mediterranean regions can be similar to that in temperate areas, but the seasonal pattern of rainfall distribution is strikingly different. For example, in Frankfurt (Germany), on the average rain falls every month of the year over a total of 173 days. In contrast, in Tel-Aviv (Israel) where rainfall amount is only slightly lower (638 and 546, respectively) rain falls during a period of about five months, for only 56 days.

Precipitation in Israel declines on a north to south gradient, from wet-Mediterranean regions in the north (>700 mm per year), through Mediterranean regions at the centre (600-400 mm per year), semi-arid in the south and eastern valley (400-200 mm per year) and arid regions in the extreme south (<100 mm per year), (Goldreich 1998). Large perennial streams are scarce and historically were situated where large karstic aquifers maintain spring flow (e.g., upper tributaries of the Jordan River at the north and the Yarqon and Taninim rivers in the central coastal region).

From the perspective of watershed formation, the most important local topographical formation is the Jordan Rift valley (a part of the Great Rift Valley), starching along ca. 400 km from the upper Galilee Mountains in the north, along the Judean and Samaria hills in the centre, down to the Arabah valley in the south. This geographical configuration divides the landscape into the western (coastal) catchment draining into the Mediterranean Sea, and to the eastern catchment draining into the Jordan valley. Streams in the Golan Heights and upper Galilee drain into Lake Kinneret (Sea of Galilee) located in the northern part of the Jordan Valley. The coastal streams are relatively short (most are <50 km), perennial or intermittent, typically lowland. Standing water and slow flowing habitats are predominant (Gasith 1992). The eastern streams are mostly intermittent and ephemeral ("Wadies"), and are relatively short, steep and fast-flowing during storm events. Selected geophysical characteristics of Israel are shown in Table 1.

Table 1: Selected geophysical characteristics of Israel.
Source: Central Bureau of Statistics, 2006

Area	**(1000 km2)**
Total area	20,700
Surface area	20,271
Lakes area	429
Sea of Galilee (Lake Kinneret)	164
Dead Sea	265
Coast line	**(km)**
Total	205
Mediterranean Sea	194
Red Sea	11
Total lakes coast line	175
Lake Kinneret	54
Dead Sea	121
Altitude	**m above/below SL***
Lowest point in the world- The Dead Sea	-421*
Lake Kinneret	-213*

Length of streams	(km)
Jordan river	172
Soreq stream	92
Qishon stream	49
Yarqon stream	25

*Sea Level – August 2008

Mediterranean-climate streams

Streams and rivers in Mediterranean-climate regions (five such regions exist globally) are physically, chemically and biologically shaped by sequential, seasonally predictable events of flooding (late fall and winter) and drying (summer and fall; Gasith and Resh 1999). Winter floods act as the stream's 'reset mechanism' which scour accumulated sediment and debris, wash away in-stream and encroaching riparian vegetation, redistribute stream-bed substrate and contribute to the mortality of organisms (Lake 1995, Gasith and Resh, 1999, Lake 2000). Drying involves a gradient of events from reduction in flow, through formation of isolated pools, to complete channel drying (Boulton 2003).

Abundance of water coinciding with mild environmental conditions during the intermediate period between flooding and drying (spring and early summer) present an ecological "window of opportunity" for the biota. Biological interactions and reproduction during this period are at their peak. The organisms found in such streams are evolutionary attuned to these seasonal sequential changes in stream conditions (Bonada et al 2007). One example is the reproduction strategy of a small cyprinid fish (the Yarqon bleak, *Acanthobrama telavivensis*), endemic to the coastal streams of Israel. It breeds in late winter and early spring, between flash floods and habitat desiccation. Breeding at this time of the year in Mediterranean-climate streams puts early stages somewhat at risk of being washed away by late floods but it also provides them a longer period of growth under favourable in-stream conditions (Elron et al. 2006).

Multiple stressed stream ecosystems

Mediterranean-climate regions are naturally water stressed because of the relatively short rainy season and the high annual water losses due to evapotranspiration during the long hot summer (Gasith and Resh, 1999). Moreover, the mild winters, abundance of sunshine and fertile soil for millennia have made the Mediterranean region attractive for human settlements and for developing intensive agriculture. This in turn led to competition for the limited resource – freshwater and to the diversion of water from streams and rivers for human use, especially during the dry season.

Israel's water resources (ca 1,800 million cubic meters) are fully exploited. The competition for water intensified dramatically during the second half of the twentieth century, following the re-establishment of the state of Israel (in 1948). Rapid population growth since the 1950's (from ca. 8% per year during the 1950's to 2% at the present, Central Bureau of Statistics 2006) and the ensuing agricultural and urban development augmented demand for water, creating severe competition by different sectors. For instance, Israel witnessed an increase in consumption of water for domestic purposes from 25% to 37 % and a decrease in use for agriculture from 68% to 56% in 1986 and 2003, respectively; (Central Bureau of Statistics 2006). This resulted in diminished freshwater available for natural ecosystems (Gasith 1992).

The aforementioned demographic growth associated with low environmental awareness resulted in severe pollution of streams and rivers (Bar-Or 2000). Except for the upper Jordan River and its tributaries that feed into Lake Kinneret (a major national drinking water reservoir), most other streams in Israel are polluted. Human activity imposes multiple pressures on the Israeli stream ecosystems. These include diversion of water directly from the stream channel or indirectly by pumping the groundwater, discharging of domestic and industrial effluents (point source pollution) and drainage of fertilizers and pesticides from agricultural runoff (non-point pollution) as well as stream bank modification and channelization as flood prevention measures. One frequently overlooked additional source of ecological stress is the salinization of water in stream ecosystems, an increasing common environmental insult, particularly in dryland regions. We describe this environmental pressure as "silent pollution" as it is colourless and odourless and often goes unnoticed. There is, however a negative relationship between biodiversity and salt content in perturbed freshwater ecosystems (Ben-David, 2005). Not withstanding, the predominant pollution stressors in Israeli streams remain organic matter and nutrients discharged into streams with municipal effluent.

Israel has emerged as the world's leader in recycling wastewater. It is estimated that from a total of ~500 Million Cubic Meters (MCM) of sewage produced each year, about 96% is collected by central sewage systems, and ca. 72% of which (350 MCM) is reclaimed (Inbar 2007, Tal 2008). Following recent consecutive drought years the proportion of reclaimed wastewater is expected to increase. The un-treated and un-reclaimed wastewaters are being discharged directly into stream channels. In the year 2000, a Ministerial Economics Committee decided to appoint an Inter-Ministerial Committee (the "Inbar Committee") for the purpose of reviewing existing regulations (since 1992) and recommending new regulations for effluent use for irrigation or for disposal to streams and receiving waters (See chapter 8).

Yet, it is not clear that these standards are sufficiently stringent to allow for stream restoration in naturally low-flowing and ephemeral streams. Consider for example two common pollution measures, the readily degradable organic matter (Biochemical Oxygen Demand - BOD) and total suspended solids (TSS). The presently recommended maximal and average concentration in discharged effluents for these two variables are 10 mg L^{-1} (Inbar 2007). Level of BOD exceeding 10 mg l^{-1} is at least two fold higher than the maximum level recorded in natural, un-polluted streams. The high level of degradable organic matter existing in the streams is usually associated with depletion of dissolved oxygen and increased mortality of aquatic organisms, diminishing natural biodiversity (discussed below under "stream health assessment").

Recent measurements of water quality in eleven selected streams in Israel indicate that in most of the streams the level of BOD and TSS far exceeds the recommended concentration (Tables 2 and 3).

Table 2: Maximum and average values of readily degradable organic matter (mg/l Biochemical Oxygen Demand) in selected streams in Israel (coastal streams from north to south, and two north eastern streams, 2000-2004; Central Bureau of Statistics, 2006)

Stream \ Year	2000		2001		2002		2003		2004	
	Max	Average	Max	Average	Max	Average	Max	Average	Max	Average
Na'aman	135	20	42	18	110	26	28	9	153	17
Qishon	96	39	38	13	34	10	16	12	31	10
Daliyya	15	7	26	13	26	14	11	5	19	7
Taninim	5	3	12	6	8	4	7	3	10	4
Hadera	153	42	45	18	452	82	62	28	297	63
Alexander	84	28	440	66	165	61	433	19	24	8
Yarqon	34	12	114	13	55	16	28	12	84	17
Soreq	353	79	120	36	292	42	42	15	253	40
Lakhish	27	12	136	30	120	32	433	77	380	47
Harod	165	29	370	51	252	42	42	15	39	20
Lower Jordan	13	4	14	6	31	10	180	52	16	8

Table 3: Maximum and average values of Total Suspended Solids (mg/l TSS), in selected streams in Israel (coastal streams from north to south, and two north eastern streams, 2000-2004; Central Bureau of Statistics, 2006)

Stream \ Year	2000		2001		2002		2003		2004	
	Max	Average	Max	Average	Max	Average	Max	Average	Max	Average
Na'aman	173	92	172	102	844	125	101	61	103	44
Qishon	95	57	454	142	352	81	508	135	177	76
Daliyya	117	41	296	99	1,346	211	95	37	78	35
Taninim	32	16	150	59	130	35	80	36	82	31
Hadera	490	89	86	46	120	64	122	48	429	102
Alexander	111	50	1,500	176	210	62	319	58	120	46
Yarqon	63	24	95	34	112	29	114	29	104	37
Soreq	168	51	160	38	1,013	156	87	27	238	47
Lakhish	1,360	360	68	23	80	39	183	60	310	73
Harod	802	253	272	149	662	206	272	97	186	90
Lower Jordan	269	67	203	51	316	90	276	100	296	71

The high level of pollution reflects the low quality of the discharged effluent, a result of relatively poor wastewater treatment in plants that still comply with the old 1992 standard of secondary effluent (''20/30'' BOD/TSS, respectively). A compounding factor is the low or completely absent dilution capacity of the streams, generally as a consequence of water diversion for human use. In some cases, if not for the effluent discharged into the stream, the channel would dry-out during the dry season (e.g. central segment of the Yarqon stream, central costal plain, and the Lower Jordan River).

Stream health assessment

The authors studied the ecological impact of secondary effluent discharged into streams under condition of water scarcity and reduced flow by assessing macroinvertebrate community integrity. This methodology is based on the notion that healthy, undisturbed streams are characterized by a rich and diverse macroinvertebrate community (high biodiversity).

Human impact significantly reduces biodiversity and enhances dominance of pollution-tolerant species. These responses can be detected and followed (i.e. bio- monitored) by sampling the community and manipulation of the data (number of species combined with species abundance) in a way that weighs the results by scaled scores. These scores are interpreted on a scale of % biological integrity which is associated with health categories (Hershkovitz 2002). This approach was used to assess the ecological state of coastal streams in Israel.

These results indicated that although recommended effluent quality for stream discharge (Inbar Committee) can improve the ecological state of streams in Israel, it is yet inadequate. For example under the recommended concentration of 10 mg L^{-1} BOD, the integrity of the macroinvertebrate community in the Yarqon stream was less then 50%. This is equivalent to a state lower than "fair" on the scale of stream health.

Trans-boundary pollution

Israel shares many of its stream catchments with its neighbours, Lebanon (Iyyon stream), Syria (the Yarmouk River), Jordan (The Jordan River) and the Palestinian Authority. Fifteen streams flow from the Palestinian Authority westward into Israel. The upper tributaries within the Palestinian Authority are naturally intermittent but presently carry sewage or treated effluent downstream. Likewise, there are polluted tributaries that originate in Israel (three major ones Harod, upper reaches of the Lower Jordan and Og stream) and flow easterly to the lower Jordan River and cross into the Palestinian Authority. A special case is that of the Hebron/Besor stream that originates in the

Palestinian Authority territory (West Bank), flows westward crossing into Israel and ultimately crosses again into the Palestinian Authority territory in Gaza Strip on the Mediterranean coast.

It is estimated that from ca. 74 MCM of sewage produced in the West bank (Palestinian and Israeli settlements) annually, only 20% is been treated before being disposed into cesspits or discharged untreated into streams (Cohen et al. 2008).
The magnitude of cross-boundary pollution was demonstrated in jointly Israeli-Palestinian research in which the authors participated, assessing conditions in two major streams and their upper-Palestinian tributaries: Hebron (El-Halil)-Besor and Shekhem (Nablus)-Alexander (Tal et al. 2008). The predominant source of pollution is raw domestic sewage or effluent as well as industrial wastes from Hebron's leather and tanning industry and limestone cutting factories. It is estimated that about 5.5 MCM of sewage per year, flow over 120 kilometres downstream until reaching Israel's Besor Reserve. This steady base flow of discharged effluents fundamentally alters the character of the stream, transforming it from an ephemeral desert stream where high quality runoff water flows for only a few days a year, to a perennial stream with a constant flow of sewage. A recent study (Hassan and Egozi 2001) showed that in ephemeral transboundary streams in the Negev and the Judean Deserts, perennial flow of wastewater enhanced the development of riparian vegetation, which reduced water velocity and increased deposition of sediment along bar edges. This process resulted in lengthening and widening of the stream bars, relative to that recorded in un-polluted situations. In addition, the channel bed of streams receiving discharges from limestone cutting factories (Hebron stream) was significantly modified.

Analysis of water quality revealed extremely high pollution as reflected for example by the levels of BOD and TSS (an average ranging from 130-500 and 700-3800 mg L^{-1}, respectively; Tal et al. 2008). Estimates suggest that between 40 to 90% of the wastewater discharged along the stream (8,000 - 11,000 cubic meters) infiltrates into the ground water along the stream's first 60 km, before crossing into Israel.

The poor water quality of the stream was also reflected in the low diversity of aquatic organisms per site (e.g., 3-11 macroinvertebrate species, such as molluscs, crustaceans, and insects), all were pollution tolerant species. Health assessment of the above two transboundary streams (Zomar/Alexander and Hebron/Besor) indicated "poor" to "very poor" state. The grave pollution state of Zomar/Alexander and Hebron/Besor streams is representative of the situation in most of the other cross-boundary streams.

Stream restoration under condition of water scarcity

Ecological restoration is an attempt to repair damage to ecosystems by eliminating or minimizing man-made effects. The term "restoration" is sometimes interpreted differently by ecologists and engineers; to overcome this obstacle we advocate using a terminology that distinguishes between different levels of ecosystem repair. Accordingly the term "*restoration*" is restricted here to situations in which the ecosystem is fully restored to its original state. "*Reclamation*" is used in connection with limited repair mostly aesthetic and "*rehabilitation*" is used when the purpose is to restore ecosystem structure and function and its ability for long-term self regulation under constraints that prevent restoring it to its original state. Together they may be termed "The triple R ecological repair". In this connection we wish to introduce a new term of ecosystem transformation that is often confused with rehabilitation. The former lacks ecosystem repair, but rather the ecosystem is transformed from one state to another. A relevant example is "greening the desert" by modifying an ephemeral stream into a perennial one, usually by discharging sewage or effluent (e.g. the Besor stream).

For the past 15 years effort is being made to restore streams in Israel. Such effort is yet to be implemented in the Palestinian Authority territory. Since the early 1990s' stream rehabilitation measures and recovery of the stream's environmental and social functions have taken an increasingly important place on the public agenda. As a result, rehabilitation master plans have been developed and partly implemented by the Israel River Rehabilitation Administration (established 1993) in cooperation with different stakeholders such as local stream authorities (e.g. Yarqon and Qishon), local municipalities, drainage authorities, The Nature and Parks Authority, The Jewish National Fund and Israeli academia (Kaplan 2004). So far the effort made in Israel to repair stream ecosystems at best has only led to reclamation.

River rehabilitation plans are conducted on different scales, from a stream section to the whole catchment basin. The rehabilitation must consider the natural hydrology of the rehabilitated stream (perennial, intermittent or ephemeral), its surrounding landscape features (e.g. natural, agricultural, and urban), the potential ecosystem services (e.g., maintaining nature's values, providing drinking water, recreation, and pollutant retention), and the social and economical benefits.

This calls for cooperative team effort by ecologists, hydrologists, engineers, economists and sociologists.

Rehabilitation of streams in Mediterranean-climate regions is fundamentally based on restoration of the unique hydrological pattern and maintaining the multi-annual flow variability. Under the situation of water scarcity allocation of water for the streams may be achieved by applying the following five management principles:

1. "Drink the water and have it too"*: maximizing reclamation and reuse of the reclaimed wastewater, primarily for use in agriculture and in industry, leaves more freshwater for nature;*

2. "Have the water and drink it too"*: stream disturbance can be minimized by letting most of the water flow in the channels and diverting it for human use furthest "downstream". Maintaining natural flows along a large stream section maximizes public gains of "ecosystem services" (e.g., recreation together with irrigation). One of the mechanisms for achieving this goal is by differential pricing for upstream and downstream pumping (adopted in Israel since 2006);*

3. "Preferential flows for spring and summer"*: Maximize restoration of the historic hydrograph pattern by discharging allocated water differentially on a seasonal basis. Rather than releasing constant amounts of water year round, more water should be discharged during spring and early summer, a period of peak biological activity ("window of opportunity" for the biota) in Mediterranean-climate streams;*

4. "Maximize water saving"*: Water stress of natural ecosystems can be reduced by maximizing saving of water. The latter can be achieved by government regulative* *intervention (e.g. differential pricing; using local arid land adapted vegetation in public parks and private gardens);*

***5. "Enlarge the cake" by desalination**: In 2008 desalination in Israel adds to the yearly renewable volume ca. 130 MCM (ca. 10%). Beyond 2010 the volume of desalinated water is expected to increase by additional 20%. However, the alarming trend of declining average annual precipitation by ca. 12% during the past 16 years (possibly an effect of global warming) may require even greater investment in desalination. In addition to enlarging the renewable volume of water, desalination will relieve the pressure of ground water withdrawal which reduces natural spring flow and threatens groundwater quality. Moreover, the added desalinated water is expected to reduce salinity of the wastewater, increasing the quality of the reclaimed wastewater.*

Water Management as if Nature Matters

In 2004 a regulation recognizing nature's right for water was introduced in Israel leading to the allocation of 50 million cubic meter of freshwater yearly for stream flow (excluding the Jordan River). Consecutive drought years and increasing water deficit in the aquifers (ca. 40% of the renewable volume in 2008) holds back implementation of this critical regulation. For the time being rehabilitation of streams using reclaimed waste water seems to be the only practical alternative. Attempts, thus far to ecologically rehabilitate the streams using wastewater effluent, however have consistently failed. To succeed using this approach will require use of high quality effluent. Use of tertiary treated effluent was recently proposed (e.g., Bar-Or 2000). However, production of high quality effluent is expensive and inherently handicapped because of the competition for this water by many sectors. The costs will surely be prohibitive for the Palestinian sector.

In order for effluent quality to be sufficient to contribute to ecological restoration, we propose using a low-tech relatively inexpensive constructed wetland technology to upgrade existing sewage treatment. In such systems the effluent flows above and through a porous medium (e.g. gravel) planted with hydrophytes. In this technology contaminants are removed by physical (e.g. filtration and sedimentation), chemical (e.g. oxidation-reduction) and biological (e.g. microbial degradation) processes. This methodology is presently planned to be applied in Israel for the Alexander and Yarqon streams and is already examined on a small scale (e.g., Dan Region wastewater treatment plant- Shafdan site; Yad-Hana waste water impoundment site).

Restoration of transboundary streams

Streams and rivers are strongly influenced by watershed processes. Therefore, cross boundary cooperation is mandatory for achieving effective rehabilitation of transboundary streams. In the present reality in the Middle East, this is easier said than done, but surely is not unattainable. Lack of adequate wastewater treatment capability, particularly at the stream source (upper tributaries) combined with the erroneous concept that one of the services of fluvial ecosystem is to transport polluted water, lead to the present grave situation of many of the streams. This conclusion comes as no surprise to anyone dealing with stream restoration. Under the poor ecological state characterizing most of the streams in the region, the first and most immediate effort must be to stop the pollution discharged on both sides of the border. Reclamation of the wastewater and reuse in agriculture and industry may be a strong incentive for diverting the polluted water out of the streams. This, however, may result in desiccation of many streams' sections, especially during the summer time. Yet, this may be an unavoidable transitional state until the potential of water in the region is enlarged by desalination.

In this troubled region the countries involved are currently unable to overcome political and economic obstacles on their own, and the assistance of the international community for achieving these goals is needed. The absurd situation of the Israeli-Palestinian reality can be demonstrated by the fact that a master plan prepared for one of the transboundary stream (Alexander stream, Brandeis 2003) won the prestigious "*Thiess Riverprize*" (Brisbane, Australia). Nevertheless, five years later the target stream is still gravely polluted. Although efforts are being made with some success to involve the international community it is time that the sides find the political will and use the help of the international community to overcome geopolitical and financial constraints that impede the implementation of this outstanding rehabilitation plan.

The success of such project may lead the way for further cooperation in rehabilitation of streams in our region.

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Editors' Summary

Stream restoration is still in a nascent stages of evolution in the region. While there has been modest and isolated improvements in several Israeli streams, the general situation is still extremely polluted and water quality is far from the natural conditions. Aquatic ecological systems have not been restored and the present conditions are not situation.

Among the clear challenges to future restoration efforts is ensuring that both parties perceive stream rehabilitation as a "win-win" dynamic. Palestinians argue that many sewage treatment plants have been built with Palestinian funds but that the treated water goes to Israel. (Furthermore, Israel, it is claimed, charges for upgrading the treatment and the utilization of water that it essentially receives for free.) In other cases, money from donors was available, but sewage treatment plants were approved by the joint committee. Given Israel's location as a down-stream riparian, in which the majority of the recreational and ecological benefits appear to accrue, it is important that future management strategies create conspicuous benefits for the quality of life of Palestinians. If such benefits are provided, the popularity of stream restoration projects will increase and the Palestinian public will have greater motivation to invest in restoration efforts. At a theoretical level, a strong Palestinian commitment to stream restoration exists and has been confirmed in "willingness-to-pay" studies. Yet, it is not clear that to date, restoration projects have been appropriately packaged to engage the local population and inform them of the potential environmental benefits.

One of the challenges in designing a cooperative transboundary restoration strategy is identifying "common uses". This is due to the fundamental asymmetry in several watersheds. Historically there was not serious flow in the upper parts of most of the sharede watersheds. Swimming and boating were not an important part of the culture in West Bank region even as some of the coastal streams served as "swimming holes" for the down-stream, rural communities.

Palestinian public perceptions justifiably see effluent-driven streams, as too small and narrow to allow for meaningful swimming in the future. A final agreement should encourage the establishment of parks along streams to draw people outdoors and establish scenic walks, sporting facilities, lawns, picnic areas, etc. – rather than facilities that focus on boating and swimming. It is unlikely that future flow will be able to support such activities. Pools could, however, be established in the adjacent parks. If flow is sufficient, then the streams could be stocked recreational fishing could be encouraged. But much remains dependent on improving access of Palestinian populations to the streams.

One possible new approach to increasing Palestinian support for investment in transboundary stream restoration is the recommending of riparian parks within the context of international economic assistance. To date the Palestinian public has minimal access to its streams. There are several reasons for this:

1) Constraints on movement associated with Israeli occupation and security concerns;
2) Control of lands by private landowners or farmers who are disinclined to turn their property into public parks without adequate compensation;
3) The lack of access roads to the streams itself.

In Israel, the situation is different with several new parks emerging along the lower portions of transboundary streams, not withstanding their poor water quality. As a result, a growing number of Israelis see the streams as tourist and picnic destinations, where in the past they were largely perceived as environmental hazards. Bike paths have been developed, observation points have been established to view unique natural assets (e.g., the soft-back turtles), and picnic areas draw large crowds on a regular basis.

Palestinian villages have few open spaces and public parks per capita are low due to past planning priorities. With the growing population density in the Palestinian sector, establishing natural “sanctuaries” for the Palestinian public would contribute greatly to general quality of life. Accordingly, among the list of possible projects for funding, along with sewage infrastructure should be a variety of urban parks and recreational infrastructures along the streams. If monies are granted for stream restoration, then funds should be available to purchase or lease the lands adjacent to the streams so that might be set aside for public use, as well as access roads to parking facilities. Local NGOs could be utilized to take a leading in planning and establishing the parks. Already, *Friends of the Earth Middle East* has launched "Neighbor's Paths" – an initial step towards of a future Peace Park. The separation fence, of course truncates the stream flow in many cases, hindering the founding Palestinian and Israeli "transboundary parks". Ideally, in a future peace agreement, physical barriers that limit stream utilization could be removed.

With 60% of the Palestinian population defined "as rural", agriculture continues to provide a livelihood to a considerable percent of the Palestinian population. At present cases, Palestinian farmers do not benefit from the treatment undertaken by Israeli facilities to improve stream water quality. If a final agreement regarding stream restoration is perceived at coming at the expense of the agricultural sector, they will not enjoy popular support. Rather, environmental agreements must be considered a "win-win" proposition for all sectors. While agricultural produce today contributes a far more modest percentage of the Israeli economy given the strength of the Israeli farm lobby and historic/ cultural affinities for agriculture, this dynamic remains true for Israel as well.

While there is some benefit in terms of stream restoration for treating sewage prior to arriving into the stream, there are of course clear hydrological reasons for treating waste water as close to the source as possible. The high percolation levels of sewage measured in several watersheds suggests that from the perspective of groundwater protection, Palestinian treatment of its waste is a top priority.

While it is likely that money can be raised to improve waste water treatment and even to establish parks around the banks, the question of the long-term financial viability of these ventures is a critical one. If the tax-base is not sufficient to support maintenance of environmental infrastructures, their performance will quickly drop. The creation of shared watershed management units is an important institutional measure, but their funding must be secured, either through governmental or international support for stream restoration and management to be successful. In addition, the creation of a variety of commercial enterprises that utilize the newly restored natural resources must be considered seriously. Park concessions – from parking lots and boat rentals to restaurants and bathrooms -- can bring in funds to ensure that the parks are well managed and clean. But the economic assessment needs to be larger in its scope.

7. Drinking Water

Historically, there have been clear links between drinking water and health with epidemics occurring in both the Israeli and Palestinian sector as a result of cholera, polio, dysentery and a host of other water borne diseases. While for the most part water quality has improved, there are no shortage of problems which require ongoing monitoring and measures to reduce exposure to contamination. These chapters consider the source of drinking water for each entity, threats to its integrity and existing regulatory frameworks for its protections.

Drinking Water Quality and Standards - The Palestinian Perspective -

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Drinking Water Resources and Supply

The Southern West Bank

The principal source of drinking water in the southern West Bank is that part of the eastern basin of the Mountain Aquifer which drains to the Dead Sea. This a deep area within the Mountain Aquifer, with a depth ranging between 800 m and 850 m in strata of Albian to Turonian age, and is made up of two principal sub-aquifers; the upper, unconfined sub-aquifer, in Cenomanian-Turonian strata, is between 50 m and 80 m higher than the lower, confined sub-aquifer, of Albian-Cenomanian age. According to borehole data, an impermeable strata of bluish green clays and marls and some chalks in the Lower Cenomanian form a separation between these two sub-aquifers.

Exploitation of this part of the aquifer is concentrated in the Herodian Beit Fajjar field and to a lesser extent further south in the Riheyeh-Samou well field, including the Fawwar wells. A more recent development is located in the Bani Naim well field. The Herodian-Beit Fajjar well field is located to the east of the line between Bethlehem and Hebron. The north-easterly plunging syncline controls the flow direction in the unconfined aquifer towards the major discharge of the Feshkha springs along the Dead Sea shore. In general terms, rainwater entering the recharge area of the phreatic aquifer in the Hebron Mountains will take about 40 years before it is discharged at Feshkha.

The Northern West Bank

There are two main aquifer systems in the northern West Bank. The Eocene aquifer is contained within a shallow synclinal structure of the flanking and underlying Upper Cretaceous strata. Groundwater flows in a north-easterly direction in the Eocene basin. As well as deep production wells for domestic uses, there are many hundreds of relatively shallow private wells utilized primarily for agricultural purposes. The relatively constant discharge rates indicate an abundant reservoir source of water

Gaza

In the Gaza Strip, the groundwater exists in the coastal aquifer (shallow aquifer), which consists mainly of sandstone, sand and gravel. The groundwater system is in fact the extension of Israel's Coastal Aquifer. The aquifer is highly permeable with a transmissivity of about 1000m2/day and the average porosity of 25%. The depth to water ranges between 70 meters in the highly elevated area in the east and 5 meters in the low land area The total annual recharge of the aquifer is estimated at 46 MCM. A deficit of 50 MCM/year is observed in the water balance due to over pumping. Therefore the aquifer is subject to infiltration from the brackish or seawater which results in a quality deterioration

2. Drinking Water Availability and Allocation

Palestine is a land that suffers from severe water stress. The full extent of the severity emerges from a comparison with international standards for per capital water availability. The World Health Organisation (WHO) (1993) sets the figure for minimum water requirements at 100m^3/cap/year for domestic, urban and industrial use plus a minimum of 25m^3/cap/year for fresh food for local consumption. In contrast, the annual supply of water for the almost 3 million Palestinians in the West Bank and Gaza for their domestic, industrial and agricultural needs is a mere 246M m^3/year. According to Israel's annual allocation, Palestinians have 93M m^3 for industrial use and 153M m^3 for agricultural use. Average per capita Palestinian supply is 82m^3/year, of which only 26m^3 is provided for domestic consumption

While there has been considerable improvement, access to tap-water is by no means universal in the Palestinian National Authority. For instance, the hill villagers, that frequently eke out a subsistence agricultural existence, lack an adequate supply of domestic water, with little available locally for irrigation. In the Bethlehem region, 89.8% of households enjoy running water in their homes, while just to the north in the Hebron Governorate, the figure remains as low as 66.3%. Supply is hardly regular; roughly a quarter experience periodic cut offs in water supply.

Palestinian water consumption is low for a variety of reasons. Chief among them are physical restrictions as well as an Israeli policy that for many years essentially froze Palestinian allocations. This created considerable resentment when new wells were drilled to provide water to Israeli settlements. Eventually, Palestinians came to focus their efforts on changing unequal distribution of water between the Israelis and Palestinians, with improvement of local efficiency or conservation taking a secondary role. At present, roughly 80% of the water from aquifers under the West Bank and Gaza is exploited by Israel, largely inside its pre-1967 borders.

Shortages of drinking water can also be attributed to domestic allocation priorities. The Palestinian agricultural sector consumes 70% of available water, even though irrigated agriculture represents only 5% of the total land available for farming.

Less than 1% of the land available for agriculture is irrigated in the southern West Bank. Palestinian agriculture in the West Bank consumes 84 Mm^3 of water.

One of the most unfortunate infrastructure problems involves widespread leakage in the Palestinian piping system. The Palestinian Water Authority estimates that the overall loss of water in the system is estimated to range between 25% in Ramalah and 65% in Jericho with an average of 44% of total supply trickling out of the system due to faulty infrastructure. In Gaza Strip, the overall loss rate is estimated at 45%, of which 35% is due to inadvertent leakage while another 10% is tapped away by unregistered connections.

The low *per capita* water consumption and water shortage in the West Bank can to a great extent be associated with the historic Israeli occupation and the artificial barriers placed on water resource development in the Mountain Aquifer among the Palestinian population. The occupation of the West Bank by the Israeli army in 1967 brought together two distinct and asymmetrical entities; the Palestinian society remained an agrarian, capital-poor, low-income economy. In contrast, the State of Israel boasted an industrial, capital-rich, high-income economy. In retrospect, the dependency of the Palestinian water system on the Israeli institutions should not be surprising.

One of the distinguishing characteristics behind the organization of the water sector on the West Bank has been the integration of services from the Israeli water supply network. The Israeli network supplied domestic water to some of the larger communities in the area from the early 1970s. Israel's Mekorot corporation involvement in water supply to the Palestinian sector undoubtedly improved the quality of life for dozens of communities who finally became connected to a fresh water grid.

From the Palestinian's perspective, however, providing a resource as essential as water was frequently perceived as giving the occupying power another form of domination. Israel can correctly respond that water supply was never used as a "weapon" to pressure Palestinians during the periodic periods of violence and military conflict. Yet Mekorot's activities undoubtedly limited Palestinian sovereignty even after the establishment of a Palestinian Water Authority (PWA) that assumed responsibility for the provision of drinking water to the Palestinian people. Palestinians quickly came to feel that Israeli authorities routinely rejected sites selected by the PWA and refused permits for drilling new wells in the West Bank.

In the long run, drinking water supply for Palestinians constitutes a serious problems. Engineers working for the PWA on new wells estimate a further 100 m drop in the water table over the next quarter of a century. Other estimates expect conditions to be far worse – far sooner, on the assumption that the eighteen new wells in the southern part of the Eastern Basin of the Mountain Aquifer will be pumping at the projected rate of $250m^3$/hr. while the seven older wells will continue to pump at their present rates. European and American donors have been blamed for bankrolling the unsustainable exploitation of the aquifer. Clearly the PWA, now in a position to supply the Palestinian population, deprived for so long, with an abundance of water, did not have conservation or even sustainability as a major priority.

3. Water Quality and Pollution

Water quality in the West Bank is generally considered acceptable. For the most part, there are no serious indications of pollution in the deep aquifer. There are, however, no shortage of instances involving contamination of water in the more shallow aquifers and springs in the West Bank. Both the Nablus and the Jericho areas, for example, have shown nitrates levels in excess of the recommended 45mg/L.

In contrast, drinking water quality in the Gaza Strip is substantially worse, with only 4 MCM out of 44.1 MCM supplied by municipal wells reaching homes at an acceptable standard (PWA, 1999).The main quality problem is the increase of salinity due to salt water intrusion from overpumping. Salinity can reach as high as 1500mg/L in the western areas of Khan Yunis and the southeastern part of Rafah governorates, a concentration that makes growing many crops practically impossible.
Equally severe is the problem of pollution from nitrates, due to the usual agricultural and sewage sources. Nitrate concentrations, also have emerged as an acute public health problem, reaching up to 400mg/L in the northern district of the Strip – almost ten times recommended concentrations.

The Water and Soil Environmental Research Unit (WSERU) at Bethlehem University noted bacterial contamination of water from three of the Mekorot wells (Abed Rabbo, *et al*. 1998). During pump testing of four of the new PWA wells bacterial contamination was also detected (CDM Morganti, personal communication, 2000 and WSERU laboratory, 2001). Karstic aquifer drainage allows rapid flow from the surface to below the water table, permitting colonial growth of coliform bacteria at depths around 250-280 m. Most of the wells penetrate the clay-marl seal separating the unconfined sub-aquifer from the confined sub-aquifer and reach depths of between 700 and 800 meters. Consideration of sectional profiles through the aquifer reveals that emptying the upper phreatic sub-aquifer seems very likely. Politicians and aid agencies deny that this is the case (PWA and USAID, personal communications, 2000). Exploitation of the confined sub-aquifer will be considerably more expensive than that of the phreatic sub-aquifer. Conservation and sustainability, despite protests to the contrary, are not treated as a priority by those political and engineering agencies engaged in exploiting the aquifer.

The area to the south of Jerusalem has two distinct regions separated by the northeast to southwest axis of the anticlinal structure forming the Hebron Mountains that contains the southern part of the Mountain Aquifer. To the east the land descends from elevations exceeding 1000 m to the Dead Sea, more than 400 m below sea level. Prevailing moist westerly airstreams deposit most of their load on the windward side of the Hebron Mountains. To the east a rain-shadow desert results from the descending air mass. To the west springs have been the main source of water until recent times. For the Palestinian population, the eastern basins of the Mountain Aquifer are now the principal source of high quality drinking water.

The results of past chemical analyses conducted offer a reasonable assessment of the suitability of the water for its designated purposes. Monitoring was based on internationally accepted chemical and biological standards for drinking water and other uses as published in WHO (1993). These results may be found in Abed Rabbo and Scarpa (2000, 2001).

The relative importance of the spring water for different groups depends on alternative sources of supply. Some communities are supplied with water derived from the deep aquifer provided either by Israeli or Palestinian water authorities. Those lacking access to such sources utilize local spring discharge, or, if they can afford it, buy water from privately owned or the PWA water tankers.

A few villages have neither network provision nor direct access to any spring and cannot afford the expensive tanker water. Many households rely primarily on rainfall collection. But collection of rainwater in household cisterns depends on an uncertain precipitation during the winter season. Rainfall in the 2001-2002 seasons seemed to return to the 1961-1990 averages (Scarpa, et al., 2002). Since that time, the very low rainfall of the subsequent rainy seasons brought considerable hardship to these villages

Of the major springs sampled in each of the three seasons (end of the dry, middle of the wet and end of the wet seasons) many were detected as having high nitrate concentrations, and are contaminated by coliform bacteria, with more than 1000 colonies/100ml. Rainfall kept in home cisterns often serves to dilute the concentration of the nitrate and the bacteria.

In another study, a detailed chemical analysis of samples collected by WSERU from the shallow wells of two unconfined aquifer systems in the northern West Bank that are utilized for drinking water, revealed substantial levels of pollution. With the low level of monitoring and regulation, there is a constant risk of potential health hazards. It is important that the Palestinian Water Authority effectively apply well protection policies and monitor drinking water quality.

The major sources of groundwater pollution in the northern part of the West Bank are ill-considered agricultural activities and careless wastewater disposal. Pollution due to agricultural activities is caused by an excessive use of fertilizer, coupled with over irrigation, facilitating passage though the unsaturated zone to the groundwater aquifer. Farmers in the West Bank use chemical fertilizers to improve their crops. The most commonly used fertilizers are ammonium sulphate, urea, potassium nitrate and super phosphate. Therefore, the most important ions added to the recharge areas of the shallow aquifer are nitrate, ammonium, potassium, sulphate and phosphate.

The pollution due to these agricultural activities is manifested in increasing levels of salinity (as measured by electrical conductivity) and nitrates. In some cases, high concentrations of potassium and sulphate are recorded. The concentration of potassium in the groundwater is normally low. This is because most of the potassium is absorbed by plants or adsorbed by mineral particles, particularly clay minerals, in the soil. Clear directives must be given to farmers concerning the safe application of fertilizers.

Uncontrolled wastewater disposal sometimes contaminates other waters causing an increase particularly in electric conductivity (EC – an indicator of salinity) values and high concentrations of chloride, sodium, nitrate and sulphate. In those areas not served by sewage systems, wastewater from septic tanks can pollute the shallow aquifer systems. Communities that are served with sewage systems, frequently have leakages from the sewage network, or from poorly sealed wastewater collection pools. This absence of an adequate infrastructure leaves raw sewage flowing from cesspits into wadis. In some cases, because of the Karstic nature of the aquifers, there can be percolation into the groundwater systems. Facilities for solid waste disposal, another potential source of pollution of the aquifers are also often inadequate.

Biological contamination is common among the shallow wells in the northern West Bank. A few of the wells were found to be chemically unsatisfactory for drinking water purposes. It is important that these shallow wells be protected and rehabilitated, where possible and proper storage facilities provided. This would facilitate upgrading the water to good potable standards by disinfection and other appropriate methods of treatment. Legislation preventing sewage disposal into wadis would provide some protection for the aquifer from this form of pollution. Cesspits are common, particularly in the rural villages, and present a pollution danger to the aquifer and spring discharge. Strict regulations requiring proper seals to cesspits or their replacement where possible, with proper sewage networks, could remove this danger. As mentioned, unregulated use of fertilizers has led to water quality degradation. This, together with excessive irrigation, a combination observed in some agricultural areas in the northern West Bank, is a source of contamination that could be avoided with proper legislation and implementation.

The quantity and quality of drinking water available from all sources, springs, rain-fed cisterns and municipal delivery networks itself, is reduced even further during the dry periods, in many cases reaching levels that represent a danger to health. Reduced flow of water in springs also reduced the quality of the drinking water in those villages dependent on spring water for the drinking supply. This presented a serious health hazard, especially for the children. Significant incidence of amoebic dysentery among both children and adults were reported in most of the villages of this study (Scarpa, 2000) The water supply from the springs and shallow wells could not accommodate even the basic domestic needs of the population.

4. Drinking Water in Gaza

The Gaza Strip has an area of 365km^2 with a population of about 2 million Palestinians. The water quality of its aquifer has for many years been so poor as to constitute a hazard when it is pumped and delivered as drinking water. This phenomenon is not getting better. There continues to be a decline in water quality from the shallow coastal aquifers that are located in an interfingering complex of sands and sandstones separated by impermeable clay seals.

Direct rainwater infiltration is about 40Mm^3/year while underground flow from the Mountain Aquifer can be 10-20Mm^3/year. However a series of Israeli wells to the east of the Gaza border extract a considerable amount of this westward flowing groundwater. Excessive exploitation of the delicate coastal aquifer is unsustainable. But with domestic water availability being extremely low (about 60L/cap/day) residents often seek to extract as much water as possible from the aquifers, legally or illegally.

Pollution to the aquifer there comes from the surface; from sewage flows and cesspits, from agricultural wastes, pesticides and fertilizers, from sea-water intrusion as a result of unregulated drilling and consequent pressure releases, and from saline waters located under the coastal aquifers, again, rising as a result of pressure release. Agricultural use of water is inappropriate but continues because of livelihood pressures, cash cropping and food security. Citrus is an extremely water-intensive crop, but remains an important cash commodity for local and foreign markets as are other water demanding crops. Wastewater treatment provides an increasing amount of irrigation water, but is not treated sufficiently.

Since the PWA has taken responsibility in Gaza, losses through leakage from pipes have declined considerably. It seems unlikely that the Gaza coastal aquifer can be saved, even if the necessary, but very difficult political decisions concerning water prioritization and allocation can be put into effect. Some form of desalination would seem to be essential for providing good quality drinking water.

5. Conclusions

For the foreseeable future, Palestinians will continue to live under conditions of significant water stress. According to World Bank estimates, the present shortfall between demand and supply is 32%, but this will reach 55% in 2020. Given existing resources, it would seem that fresh water in the region should be reserved for domestic use, with treated wastewater supplying agriculture and industry. Half a century of mismanagement, including draining wetlands and over-pumping of aquifers, has reduced the quantity and quality of available water resources in the area.

The official position of the PNA is that, in the long term, provided that Palestinians receive their full water rights, there will be a surplus for the West Bank population. This provision assumes that the present Israeli settlements in the West Bank will be evacuated leaving only Palestinians with access to the West Bank aquifers. It is to be hoped that the final status agreements reached in the bilateral peace talks between Israeli and Palestinian negotiators might lead to a more responsible shared management of these scarce water resources.

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Israeli Drinking Water Resources and Supply

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<u>Sources of natural waters and in Israel</u>

Fresh drinking water supply in Israel is based on three principal sources: two groundwater aquifers - the Coastal Aquifer and the Mountain Aquifer (the latter is also known as the Yarqon-Taninim aquifer), and one surface water source -the Lake Kinneret basin. In addition, there are a number of other minor water sources. The Coastal Aquifer extends along the Mediterranean sea shore - from Haifa in the north to the Gaza Strip in the south. The primary quality of the water in this aquifer was once excellent – with low salinity and no pollution, but over the years, this aquifer has become the most severely polluted of the three main sources. Causes for the pollution include:

1. The greater part of Israel's population is concentrated in the areas overlying this aquifer, and large industrial plants are still located over this area. Urban and industrial activities in the overlying area have resulted in the penetration of pollutants into the aquifer. The main pollutants include fuel products, heavy metals, toxic organic materials and by many micro-pollutants. The heavy metals, organic materials and micro-pollutants can cause many illnesses, including cancer and other fatal illnesses.

2. The Coastal Aquifer has undergone a process of salinization as a result of pumping in excess of its natural replenishment, irrigation with water from the Kinneret Basin (which has relatively high salinity levels), as well as irrigation with reclaimed wastewater. The chloride content of the water detracts from its suitability for agricultural irrigation, whereas its effect on potable water quality is secondary.

3. Irrigation with effluents and the general fertilization of agricultural crops give rise to increased concentration of nitrate in the water. The nitrogen oxides (nitrates) in the drinking water may cause illness to day-old babies, caused by blue-baby syndrome (cyanosis).

Water quality in the Mountain Aquifer is generally excellent. Yet, the water is exposed to a variety of pollutants that arises from the wastewater and other pollutants from settlements that are located over this area.

Israel is making many efforts to prevent the penetration of sewage or chemical contamination to the Kinneret water, and keep this water safe for drinking. Yet, the water has a high level of natural salinity, which flows into the lake from the encircling aquifers.

Illness associated with drinking water in Israel

Israel experienced a large number of waterborne disease outbreaks between 1975 and 1985, followed by a steep decline in such episodes between 1986 to 1992. Large-scale community waterborne disease outbreaks occurred primarily in 1970 and 1985. A massive public health insult caused by drinking water contamination occurred in the Krayot – the suburban region north of Haifa - in 1985. The event was attributed to a break in a sewage pipeline, that was laid near a drinking water well. Water supplied to residents of the Krayot caused intestinal diseases for more than 10,000 people. Water-associated morbidity declined from about 5 per year between 1976 to 1985, to less than one case per year between 1986 and 1992 and ceased entirely after that. It is believed that the mandatory chlorination of all community water supplies, and more stringent microbiological standards, which came into effect in 1988 were the main reasons for the dramatic progress.

The Evolution of Drinking Water treatment and standards,

Drinking water quality standards are intended first of all to assure the health of the water consumers, but also to provide palatable water, because it is important that one drinks enough water, especially in the generally warm prevailing climate. This means that the color, taste and the smell of the water must be adequate. Drinking water standards all over the world are changing in recent years, to a great extent due to the enhanced capacity to detect pollutants in minute concentrations, as well as due to new health research findings.

Israeli standards conform to general regulatory patterns found in international drinking water criteria, such as guidelines promulgated by the World Health Organization, directives of the European Communities and/or U.S. EPA regulations. In Israel, a guidance document was in effect until 1974. At that time the Ministry of Health issued the "Drinking Water Quality Regulations." These regulations have been updated about every 10 years, and recently were reviewed by a special expert's committee – known as the Adin Committee after the chairman's last name. The regulations include microbial, chemical, physical and radiological standards, as well as monitoring frequency requirements for each of these groups of standards. In general, the committee recommended that Israeli drinking water standards be set at more stringent levels.

`Since Israeli regulations are based on the leading international bodies regulating drinking water quality, (U.S. E.P.A., the WHO and the EU), standards adopted in the Israeli regulations are generally consistent with international norms. Israeli drinking water standards are divided between “recommended” levels and required levels. In some cases, such as with nitrates, there are modest differences between the concentrations that are actually allowed and the more stringent recommended standards.

Microbial standards.

Detection of pathogenic bacteria is very difficult. All microbial standards are therefore based on the detection of indicator bacteria. These standards are very strict, since small quantities of pathogenic bacteria can cause immediate illness to the water consumer. Israeli standards strive to ensure that water contain no fecal coliform bacteria. In the past, international rules allowed up to 10 coliform bacteria per 100 ml. of water. This number was later reduced to 3 and later on to 0 (zero) in more than 95% of the water sampled. The Israeli standards presently allow up to 3 coliform bacteria per 100 ml water, but the Adin Committee has already decided to reduce it to 0 (zero), commensurate with other international standards.

In order to assure this standard, and prevent the entry of parasites into drinking water, the committee suggests that all surface water be filtered (by deep sand filtration), before entering the drinking water network. The existing regulations also require that all the drinking water in Israel contain active chlorine, in order to prevent contamination within the water network.

Chemical Standards.

Chemical standards are intended to ensure public health over a consumer's lifetime. Accordingly, stringent values are set, based on empirical data suggesting that chronic exposures to these concentrations pose no risk of illness, or de minimis risk levels. The Israeli chemical standards are generally similar to those of the U.S.EPA standards or the WHO recommendations, and are also were reviewed by the expert's committee.

Chemical contamination of the aquifer waters makes it necessary to treat some of the water in order to reduce the level of contamination. One of the methods to reduce contamination of the water is by “dilution" of the contaminant with water that contains low level of a particular substance. The Ministry of Health now allows the dilution method only for organoleptic pollutants (chlorides) or other semi natural contaminants, like nitrates. The Adin Committee recommended the dilution of all natural contaminations be allowed as an effective strategy to reduce the use of chemicals in the process of the treatment.

Water parasites and viruses

Parasites (Giardia & cryptosporidium) and viruses in drinking water have already caused serious outbreaks of illness in numerous countries. The detection and elimination of such parasites and viruses are very difficult, since the chlorination has a very low effect on them. Thus, the U.S.EPA requires adequate filtration of all surface water, that ensures a reduction of water parasite and virus presence by 2 to 4 orders of magnitude. The Adin Committee’s has decided demand such treatment for all upper waters in Israel, so the turbidity of the filtered water will be not more than 0.1-0.2 NTU.

Physical characteristics of drinking water

The physical characteristics of drinking water include parameters such as the turbidity, pH, taste, odor and color of the water, that influence the palatability of the water. Turbidity also has important health effects, because it can prevent effective disinfection of the water. Therefore, over the past few decades, the maximum allowable turbidity in water was reduced from 25 NTU thru 5 NTU to 1 NTU under existing regulations. The reduction of the maximum allowed turbidity to 1 unit has led to the filtering of most of the surface water that is utilized for drinking, including water of the national carrier that derived from the Lake of Galilee (Lake Kinerret).

The Adin Committee is now discussing a suggestion to reduce it to 0.5 NTU within the water network, and to 0.1 NTU after the filtration of surface water. Such strict turbidity standards and the requisite filtration are intended to prevent the passage of parasites from surface water to the treated water.

Disinfection and disinfection by-products.

Israeli regulations mandate the disinfection of all drinking water, and demand that all of the water supply contain between 0.1 to 0.5 ppm of chlorine (or other disinfectants) in order to disinfect any contamination that can penetrate into the water network. This is essential for protection of the microbial quality of the water. On the other hand, it is well known that each disinfection process cause the formation of harmful disinfection by-products, and it is necessary that they be reduced. The main problem arises in the disinfection of surface water (such as Kinneret water) with chlorine, because of the formation of trihalomethanes (which are suspected to cause cancer). The ozonation of the Kinneret water is also problematic, since it contains a high concentration of bromine, and the ozonation can cause the formation of bromide, which is also harmful to health.

The water of the Israeli National Career (that supply the Kinneret water) is disinfected using chlorine dioxide (ClO_2) as a strong sterilizer, followed by chloramines, as a disinfectant that remains in the water system for prolonged periods. (Table 1)

Table 1. Summary of the existing Israeli main Drinking Water Standards

Element or Compound	Maximum Level (mg/l)		Element or Compound	Maximum Level (mg/l)	
Organic Substances					
1.Volatile Organic Compounds (V.O.C.)			**2. Pesticides & Herbicides**		
	[A]	**[B]**		**[A]**	**[B]**
Benzene	0.01	0.005	Ethylene dibromide	0.00005	
Benzo(a)pyrene	0.0007	0.0005	Lindane	0.002	0.001
Dichlorobenzene(1,2)	1	0.6	Alachlor	0.02	0.004
Dichlorobenzene(1,4)	0.3	0.075	Heptachlor	0.0004	
Dichloroethane(1,2)	0.005	0.004	Chlordane	0.002	0.001
Dichloroethylene(1,1)	0.03	0.01	Methoxychlor	0.02	
Dichloroethylene(1,2)	0.1	0.05	Endrine	0.002	
Trichloroethane(1,1,1)	0.2		Atrazine	0.002	
Trichloroethylene	0.05	0.03	DBCP (1,2 Dibromo-3-chloropropane)	0.001	0.0003
Tetrachloroethylene	0.04	0.01			
Chloroform	0.1	0.08	Aldicarb	0.01	
Carbon tetrachloride	0.005		Trifluralin	0.02	
Monochlorobenzene	0.3	0.1	2,4,5 TP (Silvex)	0.01	
Formaldehyde	0.9		Simazine	0.002	
Toluene	0.7		Permethrin	0.02	
Xylene	1	0.5	DDT	0.002	0.001
Styrene	0.05		2.4 – D (Dichlorphenoxy Acetic acid)	0.03	
Organoleptic Effect Parameters					
Zinc	5		Vinyl chloride	0.002	
Iron	1		Trihalomethanes (Total)	0.1	
Total solids	1500		Monochloroamines	3	
Chloride	600	400	Di(2-ethyl-hexyl-phthalate (di-octil-phthalate)	0.008	
anionic detergents	1	0.5			
Copper	1.4		**Inorganic Substances**		
Magnesium	150		Arsenic	0.05	0.01

Manganese	0.5	0.2	Barium	1	
Phenols	0.002		Mercury	0.001	
Oil and grease	0.3		Chromium	0.05	
Turbidity	1 NTU		Nickel	0.05	0.02
Ph	6.5-9.5		Selenium	0.01	
Taste and odor	Acceptable		Lead	0.01	
Color "Platinum cobalt"	15		Cyanide	0.05	
Fluorid	1.7		Cadmium	0.005	
Radioactive Radiation			Silver	0.01	
Effective radioactivity / person	0.1 mSV/year		Nitrates	70	

[A] – Existing values, [B] – Recommendations of "Adin Committee"

* – Sulphates: 437.5 ppm, minus 1.25 times the concentration of magnesium.

Monitoring of drinking water quality

Israeli regulations require that the supplier of the water control and supervise the quality of water supplies, at a frequency specified by the regulation. There is basic difference in monitoring frequency, between microbial and the chemical water tests. Bacterial contamination of the water may cause illness after drinking the water only once. Therefore the regulations require the frequent testing of the bacterial quality of the water, with monthly testing in small settlements and daily testing in large cities (population over 200,000).

The standards for chemical parameters are set at a level which permits the drinking of the water for a lifetime, without excess morbidity, and therefore the frequency of the chemical testing is low. The intervals between the testing of water sources fluctuate between one to six years, according to the level of contamination that was found earlier in the water.

According to the regulations, testing of the water quality must be done by the water supplier, including the local municipality that supplies the water to its residents. Supervision and enforcement of the regulations is conducted by the Ministry of Health.

Trends in drinking water quality

Israel suffered over the years from a shortage of fresh water, and moreover, existing sources of natural water (especially the coastal aquifer) continue to suffer contamination and are thus excluded from supplying drinking water. As a result, Israel began desalinizing sea water, to increase its water resources. It is anticipated that the contamination of the water resources will continue and Israel will be forced to increase the production of desalinized water.

The decline in the quality of the water resources raises the question of how the quality of the drinking water supply is improving. The explanation is that each contaminated source of water is excluded from supplying drinking water (usually it is transferred to supply agricultural irrigation), and so the drinking water system receives only high quality water.

Bottled water

In Israel many people drink bottled water. One of the plausible explanations for the phenomenon is the actual taste of the water itself. The taste of the chlorinated Kinerret water, that supplies most cities of Israel ia the National Carrier is often deemed offensive, and may increase the desire to drink bottled water. A new large filtration plant that treats all the National Carrier water, has begun operation and has improved its taste to some degree. Other reasons for consumer preference for bottle water may be the reports in newspapers, electronic media and even the reports of the State Comptroller, which do not distinguish between the contamination of the water in the aquifers, and the better quality of the drinking water in the water supply network.

Conclusion

Israel's drinking water quality has improved dramatically over its history. Standards have been steadily more stringent, consistent with international trends and expectations. Even as the quality of water resources themselves have deteriorated, water management interventions have for the most part prevented contamination at the faucet. Yet, the public in Israel seems to be losing confidence in the quality of its drinking water and shows a preference for bottle water, its high price not withstanding.

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Editors' Summary

There is a significant gap in the quality of drinking water available to Palestinian and Israeli households. While Israel's drinking water quality has largely improved, there are many examples of chronic contamination in Palestinian West Bank communities while drinking the much of the water supplied in the Gaza Strip has for some time been defined as unhealthy.

For the foreseeable future, Palestinian and Israeli drinking water systems will remain intertwined. Today – some 40.3 million cubic meters of drinking water is supplied by Israel's Mekorot water utility to houses in the West Bank – well over 60% of present municipal use. (An additional 3.2 million m^3 of water is still delivered by Mekorot to the Gaza Strip.) This is among the highest quality water presently available. To change the associated infrastructure and piping that supplies this water will take many years and may not make hydrological or economic sense. This means that drinking water standards between the two parties must at least be harmonized and in the long-run, should probably be identical.

While economic differences exist, the reality is that if Palestinian municpalities provide drinking water that is of poor quality, the population will simply choose to purchase bottled water. This constitutes a disproportionate economic burden on the poorest populations. Bottled water currently sells at rates of 36 cents/ liter in the West Bank. While this is orders of magnitude higher than tap water, large segments of the population are paying for it.

Adopting tougher drinking water standards through harmonization in and of itself will not be enough to improve the Palestinian situation. There are fundamental infrastructure measures which will be required for the present contamination to be reduced. For example, septic tanks will need to be cemented so that wastewater does not escape and percolate directly into the ground and reach drinking water sources. Cisterns, which in many Palestinian villages are so critical for capturing rainwater, are subject to considerable biologically contamination from bacterial outbreak, bird excrement and waterborne diseases. Because taps have filters, the population is frequently unaware of the actual water quality and illness is common. Education along with drinking water protection measures and disinfection kits are needed. Establishing and upgrading sewage treatment is of course a critical effort in virtually every Palestinian community. Here, it may make more sense to have differential standards, dependent on the ultimate use of the effluent and its potential to contaminate water resources. In either case, efforts to upgrade Palestinian water infrastructure will be extremely costly for a society whose resources are quite limited

Accordingly, a steady process of ratcheting down drinking water contaminant levels is envisioned by Palestinian experts. They compare their situation to Israel's experience. Initial Israeli drinking water standards were low and gradually became more demanding as the country's economic conditions improved. For instance, Israel understood that a standard of 90 mg/l was desirable for nitrates but couldn't afford it. Today they can make this commitment. The same is true of the BOD standard for sewage treatment. Today plants are expected to drop to 10 mg/l whereas initial standards could only require that sewage sit for five days in an oxidation pond. Frequently standards that are not

Palestinians also envision a steady phase-in of higher quality drinking water standards. It can be argued that the present contamination is so severe with pollutants that cause acute health effects (e.g., bacterial pollutants) that the correct approach should be impatience and intolerance for low standards. But for many drinking water standards, a gradual, ratcheting down strategy, based on clear timetables and quantitative targets, is one which should be considered favorably by Israeli negotiators, if common drinking-water standards become a negotiating topic.

Because Palestinians receive considerable water from springs, there must be better monitoring to ensure their integrity. But again, identifying polluted water sources is important for public health, but will not change the need to address the actual pollution sources. The Palestinian Water Authority envisions a decentralization process, by which local municipalities will play a larger role in monitoring drinking water quality. This will require consider upgrading in human capacity, laboratory and field kits, etc. This is an important area for international assistance which will both improve public health and strengthen human and scientific capacity in a new Palestinian state.

A broader, strategic question that needs to be considered in negotiations is the effect of "privatization" of water resources. While Palestinians are used to the present system which accommodates private rights, there may be less tolerance for the traditional system as scarcity becomes more severe, due to population growth and expanded contamination. Yet, nationalization of drinking water supply systems may not be an optimal solution either. Creating a regional water market has been widely advocated as an important step not only for depoliticizing water issues, but also for improving water quality. As bottled water consumption becomes a more prevalent solution, there is a slow shift in perceptions regarding drinking water. Where once people expected to be able to receive their drinking water free or at trivial prices from the tap or the well, many households now budget water as an essential commodity. Creating regional water utilities will allow households, presumably on both sides of the border, to purchase high quality drinking water at a fraction of the price which is now spent on bottled water.

8. Sewage Treatment

From a practical standpoint, upgrading sewage treatment constitutes the single most important priority for improving water quality. The rapid population growth in both Israel and Palestine has increased the quantities of wastewater produced, while there has not been a concomitant expansion of associated infrastructure. Given Israel's dependence on wastewater recycling as a source for irrigation, the quality of effluents has special importance. This chapter considers the issue of sewage treatment from the very perspectives of the two sides.

Sewage Treatment in Gaza and the Quest to Upgrade Infrastructure

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.1.1.1 1 Introduction

The Gaza Strip is one of the most densely populated areas in the world with a population of 1,472,000 in year 2005 and an area of only 365 km^2. The Gaza Strip is located in a semi-arid area where water resources are scarce. Due to increasing groundwater pumping for human use as well as for irrigation purposes, the extraction of groundwater currently exceeds the recharge of the groundwater aquifers. As a result, the groundwater level is falling and the salinity is increasing making the water unsuitable either for human consumption or for irrigation purposes. The environmental situation in the Gaza Strip is critical: Depletion of water resources, deterioration of water quality, shoreline and marine pollution, and land degradation. This needs regional and international efforts to enhance and protect it.

Reclaimed wastewater reuse for agriculture has been recognized as an essential component in the management strategy for water shortage in the neighboring countries. Like arid and semi arid countries, reuse of treated wastewater in agriculture is gaining more attention in developing strategies for planning and developing of Palestinian water resources as it represents an additional renewable and reliable water source, which would reduce the water deficit and the decline in groundwater quantity and quality.

There are several benefits in using treated wastewater:

- First, using treated wastewater for irrigation will reduce the demand on the groundwater for irrigation and will preserve high quality and expensive fresh water for potable use and would reduce the degradation of the groundwater quality.
- Second, collecting and treating wastewater protects existing sources of valuable fresh water, the environment, and public health.
- Third, if managed properly, treated wastewater can sometimes be a superior source for agriculture than fresh water sources. It is a constant water source, and nitrogen and phosphorous in the wastewater may result in higher agricultural yields than freshwater irrigation, negating the need for additional fertiliser application.

.1.1.2

.1.1.3 2. Current situation of wastewater in the Gaza Strip

Currently, there are three wastewater treatment plants (WWTPs) in operation in the Gaza Strip receiving about 24 Mio.m^3 of raw sewage per year namely: Beit Lahia, Gaza and Rafah WWTPs (Table 1). In the Mid Zone there is no WWTP, instead wastewater is collected through sewage network and pumps directly into Wadi Gaza without any treatment. Such sewage network is recently established in Khan Younis Governorate to serve only 25% of the population, however, this network is not operated till now and the people are still widely used cesspools.

Table 1. Wastewater treatment plants existing in Gaza Governorates

Governorate	Name of	Year of establishme	% Population	Processes	Inflow* Mm^3/ye	Outflow

	WWTP	nt	connected		ar	
Northern	Beit Lahia	1978	78	2 anaerobic ponds, 2 aerated lagoons and 3 stabilized ponds	2.8 (D) 5.5 (A)	surrounding sand dunes (artificial lake)
Gaza	Gaza	1977	85	2 anaerobic ponds, one aerated lagoon and 2 trickling filters	11.7 (D) 19.8 (A)	Mediterranean Sea and Wadi Gaza
Mid Zone	-	1997	70	no treatment	0.0 (D) 3.5 (A)	Wadi Gaza
Khan Younis	-	2004	25	not operated	-	-
Rafah	Rafah	1982	60	one aerated pond and one lagoon	0.7 (D) 2.7 (A)	Mediterranean Sea

* D: designed flow, A: actual flow

Source: Palestinian Water Authority (2005)

The existing WWTPs currently produce primary and secondary effluents only, based on the pond system of treatment. As a result of rapid population growth, the actual flow of the three WWTPs far exceeds the design flow, leading to overloading and flooding of wastewater. Such floods in the Beit Lahia-WWTP created an artificial lake of about 35 ha in the surrounding sand dunes. Most of the effluent produced in the Gaza-WWTP is discharged to Wadi Gaza and from there it flows to the Mediterranean Sea, representing significant loss of water resource and a violation of the international ban on land-based source discharges into the Sea

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The biological and chemical properties of effluent of the Gaza WWTP in the year 2005 are shown in Table 2.

Table 2. Current effluent quality (chemical and biological) of the Gaza wastewater treatment plant.

Parameter	Value	Unit
BOD	37.3 (74*)	mg/l
COD	111.2 (230*)	mg/l
TSS	59.1 (175*)	mg/l
pH	7.79	
EC	3.13	mmhos/cm
Ammonium-N	72.6	mg/l NH_4^+
Nitrate	35.9	mg/l as NO_3^-
Chloride	576.4	mg/l as Cl^-
Sulfate	128.9	mg/l as SO_4^{-2}
Potassium	31.3	mg/l as K^+
Sodium	377.5	mg/l as Na^+
Alkalinity	520	mg/l as $CaCO_3$
Copper	0.6	mg/l as Cu^+
Boron	1.2	mg/l as B
Fecal coliform	2.6E+06	CFU/100cm

* = Average values of months Jan., Feb., and March 2007

Source: Palestinian Water Authority (2005)

Effluent from the existing Gaza WWTP is currently being used by farmers through pilot projects funded by the Spanish and French governments, principally for irrigation of citrus and olive trees in Gaza area (around 100 dunums) and forage crops in North area (40 dunums).

It is proposed to construct three new WWTPs in the North, Middle and South zones of the Gaza Strip, that will replace the existing ones with an effluent capacity reaching 116.8 Mm^3 in year 2020. Effective and economical management of the effluent reuse system is essential for the long-term success. With the planned construction of three regional WWTP's, it is widely recognised that the treated effluent provides an opportunity to reduce the current reliance of farmers on groundwater for irrigation both by direct supplies to farm land and indirectly by recharge to the aquifer.

3. Effluent Standards

Palestinian Standards for effluent quality and limit values for its reuse are broadly consistent with those of neighboring countries. Standards for effluent reuse have recently been adopted (PS 742/2003). Four classes of effluent quality are recognized (Table), classified by BOD, TSS and fecal coliform concentrations. The heavy metal limit concentrations given in the Palestinian Standards fall broadly in line with values commonly adopted internationally. The following hygiene standards are recommended for effluent reuse in irrigation, for which fecal coliform (FC) is used an indicator of potential pathogen content in the effluent at the point of irrigation:

* <1,000 MPN FC/100 ml for restricted reuse, including crops normally eaten cooked, fruit trees, etc.

* <200 MPN FC/100 ml for unrestricted reuse, including crops normally consumed uncooked and green areas with public access.

* <1 nematode ova/l for all reuse by irrigation

These recommendations are consistent with WHO guidelines,

Table 3: Classification of Effluent Quality (PS 742/2003)

Class	Quality	BOD (mg/l)	TSS (mg/l)	Faecal coliform (MPN/100 ml)
A	High	20	30	200
B	Good	20	30	1,000
C	Medium	40	50	1,000
D	Low	60	90	1,000

Table 4. Comparison of Expected Effluent Quality from

Central Gaza WWTP with Local Quality Standards

Parameter	Expected effluent quality New WWTP	Palestinian Standard (PS742/2003)	
		Irrigation	Recharge
BOD (mg/l)	20	20 – 60	20
TSS (mg/l)	30	30 – 90	30
TDS (mg/l)	1800	1500	1500
EC (μS/cm)	2700	-	-
T-N (mg/l)	25	45*	100*
Na (mg/l)	430	200	230
Cl (mg/l)	550	500	600
SAR	8	9	-
B (mg/l)	0.6	0.7	1
F. coliforms (MPN/100 ml)	10^6	200 – 1000	200 – 1000

* Sum of nitrate, ammonia and organic N limit values

3. EFFLUENT MANAGEMENT CONCEPT

It is by now well-established that treated effluent must play a key role in re-establishing a water balance in the Coastal Aquifer to aid sustainable development in the Gaza Strip. This will require farmers to substitute effluents for groundwater as the principal irrigation source, wherever feasible, and for effluent that is surplus to agricultural demand, to be recharged to the aquifer.

.1.1.4

Such a strategy is recognised as optimal and could be implemented in an integrated and flexible manner, according to strategic water management decisions and demands for water:

1. Irrigation of agricultural crops is the only feasible option for the direct reuse of treated effluent that will also reduce the reliance of farmers on wells. Existing irrigated crops that are currently suffering yield reductions due to the high salinity of the groundwater, particularly citrus in the area), should recover some of their yield potential and return to more economic levels.

2. Aquifer recharge by strategically located infiltration ponds is clearly identified as a crucial component of effluent reuse strategies in Gaza. The major advantages with regard to the local water resources are:

- Recovery of declining groundwater levels and reduction of salinisation of the aquifer from sea water intrusion and upconing of saline.
- For recharge purpose, the hydrogeological conditions in Gaza Strip will provide effective filtering of any pathogens within the surface layer. Nonetheless, additional treatment of effluent at the WWTP would be advisable to minimize the loading of solids on the filtration surface

3. Discharge to Wadi Gaza has the potential to improve the environmental conditions and recreational potential of the area.

.1.2 4. Willingness to Use and Pay for Reclaimed Water

One of the main concerns is willingness of farmers to use treated wastewater for agriculture. A number of surveys have been conducted in the context of studies on the reuse of reclaimed water which dispel concerns about cultural barriers to waste water recycling. In Northern Area, the results mentioned by Tubail et al. (2004) is that 86.1% of all interviewed farmers accepted the use of reclaimed water for irrigation.

The general acceptance level for using reclaimed water for irrigation in Gaza and Middle area is very high (89.9% of all farmers). This finding is consistent with the results of previous surveys. The most important reason for wanting to use reclaimed water as an alternative to groundwater is related to anticipated higher incomes, either due to irrigation cost reductions or improved yields. On average, farmers would be willing to pay 0.36 NIS/m^3. Farmers expressed a number of concerns about reclaimed water regardless of their acceptance or refusal to use it for irrigation. Their principal concern is that customers might refuse to buy their products if they become aware about the source of irrigation water.

5. Strategic Assumptions and Implications

Future Palestinian sewage policy can rely on several assumptions:

* Farmers are willing to use and pay for effluent;

* The quality of the effluent is suitable for the intended outlets will need to be in compliance with appropriate standards.

* The cropping practices of farmers can be controlled to ensure that specific crops (mainly vegetables) are not grown where restricted reuse is necessary.

* The Coastal Aquifer can accept large quantities of effluent by artificial recharge at appropriate locations that will benefit groundwater levels and reduce saline intrusion.

Potential Impacts

The main implications of the current Palestinian effluent reuse standards are that some parameters are significantly more stringent than the well-established WHO and FAO guidelines as follows:

* The limit values set for salinity and chloride concentrations would prevent any reuse of effluent in agriculture or aquifer recharge;

* The standards set a limit for effluent recharge of 25 mg N/l and an equivalent concentration of 110 mg NO_3/l. At this level, the effect would be to increase, or at least maintain, the currently high concentrations of nitrates in groundwater.

* Exclusion of all vegetable crops from effluent irrigation is considered unnecessarily restrictive since the hygienic standards for effluent are appropriate for unrestricted reuse and meet the WHO guidelines.

The area in Gaza in which vegetables grown has increased from 26% of the agricultural land to 44% during the last years (MOA statistics 2001, 2004). A fecal coliform limit of <200 MPN/100 ml should be adopted for unrestricted reuse on all crops. For irrigation and aquifer recharge, PWA has already recommended criteria for effluent quality standards in Gaza as shown in Table 5.

Table 5. Criteria Recommended by PWA for Effluent Standards in the Gaza Strip

Criteria	Recharge by infiltration	Restricted irrigation	Unrestricted irrigation
BOD (mg/l)	10 – 20	10 - 20	10 - 20
SS (mg/l)	15 – 25	15 - 20	15 - 20
T-N (mg/l)	10 – 15	10 - 15	10 - 15
Helminths (no./l)	-	<1	<1
Faecal coliform (no./100 ml)	-	<1,000	<200

Additional Effluent Treatment

The new Palestinian WWTPs must be designed to achieve an effluent quality suitable for discharge to Wadi Gaza. However for reuse, additional effluent treatment is considered necessary to achieve:

- *Disinfection:* Sewage treatment should reach a level that will permit unrestricted reuse for irrigation. The minimum level of pathogen and parasite removal should achieve WHO guidelines (fecal coliforms <1,000 MPN/100 ml and nematodes <1 ovum/l).

The technical means to achieve this have been reviewed and, from practicable, environmental and economic perspective, the following are recommended: Rapid sand filtration and UV disinfection.

- *Nitrogen Removal"* The design of the WWTP is also expected to achieve a maximum total nitrogen concentration in effluent of 25 mg N/l. Further reduction of nitrogen is considered necessary for the recharge of effluent to protect the groundwater from additional loading of nitrate and to allow gradual rehabilitation of groundwater quality. A standard of 10 mg N/l is broadly equivalent to the WHO standard for nitrates in drinking water and is considered appropriate.

In order to reach these concentrations, oxygen must be during wastewater treatment provided by aeration. The second step of nitrogen removal, denitrification, is the reduction of the nitrate to elemental nitrogen (N_2).

- *Effluent filtration* Both irrigation and aquifer recharge of effluents require a low content of suspended solids (TSS). Effluents with low suspended solids are also necessary to reduce the risk of clogging drip irrigation emitters and the infiltration surface of recharge ponds.

The WWTP will need to be designed to achieve about 30 mg TSS/l, which is acceptable for irrigation and recharge, but for efficient disinfection the suspended solids should be reduced to 10 mg/l or less. Rapid sand filters are recommended as the most cost-effective option.

Conclusion

It has been well-established by previous strategic studies that treated effluent must play a key role in re-establishing a water balance in the Coastal Aquifer to aid sustainable development in the Gaza Strip. This requires farmers to substitute effluent for groundwater as the principal irrigation source, wherever feasible, and for effluent that is surplus to agricultural demand to be recharged to the aquifer. The existing three WWTPs in Gaza strip are overloaded and poorly operated. As a result, the three new planned WWTPs should be engineered ni order to produce substantial quantities of treated effluent; these are valuable agricultural resources. But successful treatment and reuse requires careful planning and management to ensure that appropriate quality standards are achieved and the maximum sustainable benefits are realised economically.

For unrestricted reuse of effluent to be acceptable, additional effluent treatment is necessary for which rapid sand filtration and disinfection by UV are recommended as the most suitable options. Nitrogen removal from effluent that is recharged is required to protect and improve groundwater quality.

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Wastewater Treatment and Reuse in Israel

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Introduction

The total area of arable land in Israel has increased from 1,600 square kilometers in 1948 to approximately 4,200 square kilometers in 2001. Irrigated land has increased from 300 square kilometers in 1948 to 1,866 square kilometers in 2001. Water scarcity has traditionally been the primary limiting factor in Israeli agriculture. Agriculture is the number one factor in the protection of open space and prevention of desertification. It also serves as a sink for waste produced in the urban sector, including effluents, sewage sludge or compost.

The combination of severe water shortage, densely populated urban areas and highly intensive irrigated agriculture, makes it essential that Israel put wastewater treatment and reuse high on its list of national priorities. In fact, national policy calls for the gradual replacement of freshwater allocation to agriculture by reclaimed effluents. In the past, sewage has constituted a major source of water pollution. Yet, a steady process of sewage infrastructure expansion has improved the situation dramatically, with only isolated cases remaining of untreated sewage. Currently about 72% (> 300 million cubic meters (MCM)) of the wastewater produced in Israel is reclaimed for agricultural reuse.

A new standard for unlimited use of effluents was recently adopted by the government. The standard, encompasses 36 parameters, taking into account public health, soil, hydrological and flora considerations. This new standard will enable the re-allocation of nearly 50% of all fresh water (about 500 MCM), from agriculture to the municipal and industrial sectors. The operational objective is to treat 100% of the country's wastewater to a level enabling unrestricted irrigation by the year 2010 in accordance with soil sensitivity and without risk to soil and water sources.

Wastewater

Out of a total of 500 MCM of sewage produced in Israel, about 96% is collected in central sewage systems and 67% of the effluent is reclaimed (300 MCM). By law, local authorities are obligated .to treat municipal sewage. In recent years, new or upgraded intensive treatment plants were set up in municipalities throughout the country. The ultimate objective is to ensure that all of Israel's wastewater is sufficiently clean to allow for unrestricted irrigation in accordance with soil sensitivity and without risk to soil and water sources.

The following facts provide a synopsis of the condition of Israel's municipal sewage profile:

- Some 500 MCM of wastewater are produced in Israel every year, of which 450 MCM/y is treated.
- Some 330 MCM per year of the effluent is reclaimed (about 72%)
- Some 4% of the wastewater is discharged to cesspools (20 MCM)
- Some 96% of the waste is collected in central sewage systems
- Some 33% o the wastewater/effluents is discharged to the environment (approx. 160 MCM)

Wastewater Treatment Plants

There are upwards of 500 sewage treatment facilities in Israel today, of which some 35 are advanced wastewater treatment plants (purifying over 360 MCM/y) with minimum annual capacity of more than 0.5 MCM each. Recently, Israel has begun to divert Palestinian sewage that flow over the green line in waste treatment plants to prevent contamination of streams and groundwater.

Regulations promulgated by the Ministry of Health in 1992 require secondary treatment to a minimum baseline level of 20 mg/liter bio-chemical oxygen demand (BOD) and 30 mg/liter total suspended solids (TSS) in urban and rural centers with populations exceeding 10,000 people. Local authorities are responsible for the construction and operation of wastewater treatment plants.

Israel's wastewater treatment plants use intensive (mechanical/biological) and extensive treatment processes. Intensive treatment plants use activated sludge methods while extensive processes are based on anaerobic stabilization ponds, which are integrated with shallow aerobic ponds and/or deep facultative polishing reservoirs. Treatment facilities may include nitrogen and phosphorous removal. After treatment, the effluent is placed in seasonal reservoirs, which also serve to regulate the constant flow of treated wastewater and the seasonal demand for irrigation.

Wastewater Treatment

Because of the combination of severe water shortage, contamination of water resources, densely populated urban areas and intensive irrigation in agriculture, wastewater treatment and reuse are high on Israel's list of national priorities. There appears to be a steady improvement in the quality of sewage effluents produced. In 2001, some 46% of the effluents produced in the country (200 MCM) complied with the standards set in regulations (20/30 BOD/TSS). This number reached 60% (256 MCM) in 2002 and 72% (300 MCM) in 2005.

The organic load in Israel's municipal wastewater is much higher than in the western world. Furthermore, due to the high rate of effluent reuse for irrigation purposes, environmental sensitivity to the salt content of sewage is especially great.

The adverse environmental impacts of domestic sewage may be reduced through the following activities:

1. Reduction of salt emissions to the sewage system through discharge of industrial brines to sea as well as reduction in the use of salt in dishwashers and laundry detergents.
2. Changes in the chemical composition (especially reduction of boron) of detergents to environment-friendly materials.
3. Legislation to limit the use of domestic garbage grinders (in Israel, each person generates some 0.5 kg of organic waste per day, use of garbage grinders and disposers would increase the organic load in wastewater treatment plants tenfold.)
4. Steps to assure that industrial sewage discharged to municipal treatment systems will undergo pretreatment to remove toxic or harmful materials.

Effluent Disposal and Reuse

Sewage treatment effluent is the most readily available water source and provides a partial solution to the water scarcity problem. National policy calls for the gradual replacement of freshwater allocations to agriculture by reclaimed effluent. In 1999, treated wastewater constituted only about 22% of the consumption by the agricultural sector. It is estimated that effluent will constitute 45% of the water supplied to agriculture in 2010 and 50% in 2020.

The Ministry of Health maintains a permit system designed to ensure that irrigation with effluent is limited to non-edible crops such as cotton, fodder, etc. Only highly treated effluent, after disinfection, is used for irrigation of orchards, such as citrus groves avocado and others. Effluent is not used for irrigating crops in which there is direct contact between the water and the edible part of the plant (e.g., lettuce).

Upgraded Effluent Quality Standards

Because of the decision to increase the use of effluent to a total of 500 million cubic meters, the Ministers Committee for Economics (Decision 46, July 2000) decided to nominate an Inter-Ministerial Committee ("Inbar Committee") in order to review existing and recommend new regulations for the use of effluents for irrigation or for disposal to streams and receiving waters.

The recommended values, designed to minimize potential damage to water sources, flora and soil, call for much higher treatment levels in existing and future wastewater treatment plants. An agreement in principle has been reached on the new effluent quality standards, and a techno-economic review of the standard has been conducted. The objective is to treat 100% of the country's wastewater to a level enabling unrestricted irrigation in accordance with soil sensitivity and without risk to soil and water sources.

The proposed regulation included 36 biological and chemical parameters classified in three groups (Table 1):

- **Organics, Nutrients and Pathogens:** BOD, TSS, COD, Fecal *coliforms*, Dissolved Oxygen, Residual Chlorine, Mineral Oil, pH, Total Nitrogen, Ammonia and Total Phosphorus
- **Salts:** Electrical Conductivity (TDS), SAR, Chloride, Sodium, Boron, and Fluoride
- **Heavy Metals:** Arsenic, Barium, Mercury, Chromium, Nickel, Selenium, Lead, Cadmium, Zinc, Iron, Copper, Manganese, Aluminum, Molybdenum, Vanadium, Beryllium, Cobalt, Lithium, and Cyanide

Table 1. Proposed New Israeli Standards for Effluent (Average Levels) *

Parameter	Units	Unrestricted Irrigation*	Rivers
Electric Conductivity	dS/m	1.4	n/a
BOD	mg/l	10	10
TSS	mg/l	10	10
COD	mg/l	100	70
$N\text{-}NH_4$	mg/l	20	1.5
Total nitrogen	mg/l	25	10
Total phosphorus	mg/l	5	1.0
Chloride	mg/l	250	400
Fluoride	mg/l	2	n/a
Sodium	mg/l	150	200

Faecal coliforms	Unit per 100 ml	10	200
Dissolved oxygen	mg/l	>0.5	>3
pH	mg/l	6.5-8.5	7.0-8.5
Residual chlorine	mg/l	1	0.05
Anionic detergent	mg/l	2	0.5
Mineral oil	mg/l	n/a	1
SAR	$(mmol/L)^{0.5}$	5	n/a
Boron	mg/l	0.4	n/a
Arsenic	mg/l	0.1	0.1
Mercury	mg/l	0.002	0.0005
Chromium	mg/l	0.1	0.05
Nickel	mg/l	0.2	0.05
Selenium	mg/l	0.02	n/a
Lead	mg/l	0.1	0.008
Cadmium	mg/l	0.01	0.005
Zinc	mg/l	2	0.2
Iron	mg/l	2	n/a
Copper	mg/l	0.2	0.02
Manganese	mg/l	0.2	n/a
Aluminum	mg/l	5	n/a
Molybdenum	mg/l	0.01	n/a

Vanadium	mg/l	0.1	n/a
Beryllium	mg/l	0.1	n/a
Cobalt	mg/l	0.05	n/a
Lithium	mg/l	2.5	n/a
Cyanide	mg/l	0.1	0.005

*From soil, flora, hydrological and public health considerations

To achieve the threshold values recommended for the parameters in the regulation, the quality of the effluent must be upgraded. The way to reach this objective will be different for any group of parameters. The group of Organics,

Nutrients and pathogens can be treated at the wastewater treatment plants, under present conditions or with some technical upgrading. Salts and heavy metals, at the present level of wastewater treatment, have to be treated at the source. Therefore, recent years have seen a flurry of new regulations (by the Ministry of the Environment in collaboration with other ministries) designed to improve wastewater quality. In some instances, regulations are based on European standards (e.g., regulations limiting the discharge of heavy metals); in others, they are specifically developed to address conditions that are unique to Israel (e.g., regulations prohibiting the discharge of brines into municipal sewage systems and detergent standards setting limits on concentrations of chlorides, boron and sodium). Special attention is currently being given to problems relating to the high salinity of municipal sewage. This is an issue of particular importance in Israel, where wastewater recovery for agricultural purposes is imperative.

Conclusions

Israel's experience with wastewater reuse suggests that it can be an invaluable component in water management strategy for dry lands. However, there are strong public health and environmental implications, which must be considered prior to adopting a final policy. A water management system, which is not based on extremely high treatment levels, will not be sustainable or beneficial in the long run. Inadequate sewage treatment limits the range of crops that can be safely grown with wastewater irrigation. Consequently, the Government of Israel decided to upgrade its treatment of effluents to the above proposed advanced standards enabling unrestricted irrigation in accordance with soil sensitivity and without risk to human health, flora, soil and water sources. Despite the apparent progress domestically, the lack of adequate treatment of Palestinian sewage is not a problem that Israel can ignore as it pursues its water quality goals.

Editors' Summary

There is probably no area in water management where the gap between Palestinian and Israeli environmental performance is greater than sewage. While Israel's present level of treatment is often lacking, the present infrastructure and treatment levels are world's apart from those that existed fifteen years ago. At the same time, despite the general sense of progress, some of the assumptions about future waste water utilization in Israel may require reconsideration. For instance, as urbanization expands in some regions, the agricultural demand for waste water will continue drop. Ultimately, transferring effluents great distances to where demand exists may make less economic sense. As the ecological integrity of streams improves, there will be a need to continually improve waste water treatment, and better fresh water sources will be expected. Many environmentalists also argue that the country has made an adequate commitment to sewage infrastructure and that many municipal governments have found other areas to spend local taxes. But if present trends are any indication, it is fair to assume that Israel will continue to expand its usage of sewage treatment and that the quality of effluents will continue to improve.

While Israel has made slow but steady progress first in connecting homes to sewage systems and then upgrading its level of treatment, sewage treatment remains anomalous for the vast majority of Palestinian communities. Existing treatment facilities suffer from lack of maintenance and are increasingly overwhelmed by the growing organic loadings that have come with the population increase. Palestinians have not made sewage treatment a high enough priority. The long–term impact on soil and water resources is still not well characterized but should be a source of apprehension. The effect of mosquitoes, poor odors and periodic outbreaks of related diseases is more apparent and of immediate concern to the general public. In the context of future negotiations sewage treatment constitutes environmental priority number one. Any negotiated solution and international assistance should reflect this commitment.

There is also probably no other area of water management (with the possible exception of overpumping) where there is a greater need for coordination between Israelis and Palestinians. The integrity of ground water or the aquatic systems in local streams will never be ensured unless dramatic improvement takes place. Common standards for sewage treatment are important because of the impact that sewage discharges have on shared water resources. It is clear from Israel's experience that recharging aquifers with poorly treated sewage will ultimately degrade groundwater quality. Massive irrigation with poorly treated effluents has also led to groundwater contamination, with industrial solvents appearing in wells throughout Israel's coastline, when they were not removed in wastewater treatment plants. Salinization of soils and wells is often attributed to Israel's alacrity to utilize waste water. But there is a limit to the demands that can be made in an international agreement when the issue of sewage treatment standards arises.

There is a link between environmental infrastructure and economic conditions. Several Palestinian sewage treatment plants have been established that ceased to function effectively due to lack of funding. Donors should ensure that financial mechanisms are in place to prevent these dynamics from occurring in the future. More importantly, the limitations of present capacity have clear implications for the establishment of common treatment standards. Essentially, "perfection" is indeed the enemy of the "good". Better to install reasonable secondary treatment across the board, then to have expensive tertiary treatment facilities that are not functioning.

A critical question that needs to be addressed in negotiations involves a coordinated response to the present "transboundary" dynamics of sewage treatment. In recent years, Israel unilaterally has begun to establish treatment facilities to capture and treat Palestinian sewage as it crosses the border. This was initially described as a pragmatic response, taken to protect Israeli water resources given the lack of progress in Palestinian waste water treatment. But it is not clear whether what was once an exigency has turned into a strategy. It, it is now clear from hydrological research that much of the sewage flowing from the Palestinian Authority percolates into the ground prior to reaching the Israeli treatment facility. A substantial percentage of this "lost" wastewater will make their way to the groundwater.

Accordingly, a final agreement about water should therefore internalize a fundamental axiom of environmental management: the proximity principle. The proximity principle holds that it is essential that water be treated as close to its source as possible. While future infrastructure and normative frameworks should consider waste treatment and *utilization* of effluents at a *regional* level, the focus on *treatment* must be local. Alternatively, and in the interim, untreated wastes can be transported to regional treatment centers via pipelines in order to prevent water loss/contamination and the risk of human exposure while it is in transit.

Until this principal is applied, there remains the thorny issue of costs. Israel has traditionally charged Palestinians for treating their waste in ad-hoc facilties in Yad Hana and in Nahal Beer Sheva. It has not, however, been willing to pay out similar funds in areas like the Kidron valley where Israeli sewage are a source of pollution in the Palestinian Authority. Palestinians justifiably object to this asymmetry. Moreover, they perceive the interim agreement, which requires high levels of coordination with Israel as one of the primary reasons why there has been so little progress in upgrading their sanitary infrastructure during the past decade.

Surely, it is in Israel's hydrological self-interest to facilitate the construction of Palestinian sewage treatment plants – either via monies donated by international donors or generated by local taxes. Moreover, in the long run, siphoning off Palestinian "tax funds" for a sub-optimal sewage plant in Israel will make no sense hydrologically. Eventually, Palestinian plants and reuse of waste will render these facilities useless in any event. Israel should think about making strategic investments from its own funds in Palestinian infrastructure – over the border and close to pollution sources. A long term "sustainable" allocation of water region will require both Israelis and Palestinians to utilize treated effluents in agriculture and as part of their stream restoration program.

9: Agriculture and Water

Agriculture constitutes the greatest consumer of water in both the Israeli and the Palestinian economies. Besides its dominant role in water quantity issues, agriculture contributes a variety of pollution sources. Given its central role in both Zionist and Palestinian culture and the fact that food is not an ordinary product, clearly, public policy towards agriculture will be different than for other industrial sectors. It is also clear that agriculture is no longer perceived as an "environmental adversary" but rather a partner in a sustainable solution to water issues. This chapter considers the unique role of water for each side by two experts who are known for their expertise in sustainable agriculture

Sustainable Water Supply for Agriculture in Israel

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Development and structure of modern Israeli agriculture

Since the beginning of the Zionist resettlement in Palestine around the turn of the 20th century, Jewish presence has possessed a strong agrarian emphasis. Early pioneers believed in farming as an ideology that was needed to transform the occupational and social structure the Jews had in Eastern Europe into a natural organic national structure rooted in the soil. The preference for agrarian living was also thought to assist in transforming the Jews into a nation "like all other nations" (Elon 1971). In addition to its ideology, the early Jewish agricultural society was defined by rejection of traditional Middle Eastern farming and alternatively adopting and applying modern European cultivation approaches. Traditional agriculture of the time was fairly unsuccessful with low yields, little irrigation and no sense of land or soil conservation. The Zionist farmers, on the other hand, introduced soil conservation techniques, irrigation and mechanized cultivation.

Israel's agriculture remains organized on cooperative principles which evolved during these first decades of the 20th century. Two unique forms of agricultural settlement, the Kibbutz and Moshav, continue to dominate the Israeli agricultural landscape. The Kibbutzim (plural Kibbutz) are collective intentional communities while the Moshavim (plural Moshav) are rural villages with a more modest cooperative base. Both reflect the early pioneers' vision of rural agricultural communities based on social equality, cooperation and mutual aid. Today, Kibbutzim and Moshavim continue to provide most of the country's fresh produce as well as processed food products, and almost all meat poultry and fish.

Upon the founding of the State of Israel, large numbers of immigrants arrived to join the early settlers. The new government actively settled immigrants in agriculture-based communities, many situated in the arid southern, sparsely populated part of the country, as a vehicle to assume ownership of the land. In addition, both pre-and post-state agricultural communities functioned as strongholds against military threats. The agricultural communities became the core of the nation's ethos and many of their people belonged to the cultural, political, and military elite of the country. "Making the desert bloom" has become a national goal and slogan; making agriculture importance rise above mere food production and security.

The period of high immigration in post-state Israel was accompanied by tremendous expansion of agricultural production, much of which was due to increased irrigation. Early state agriculture was highly supported by the government; water was subsidized; price supports were offered for many basic crops; disaster relief was provided. A highly professional extension service brought state of the art agricultural practices to the farmers; research was funded generously. The Ministry of Agriculture in Israel currently still invests some 70 million dollars a year in agricultural research.
Water was made available for irrigation.

Up until a decade ago, the management of national water resources was the responsibility of the Ministry of Agriculture. Typically, the Director-General of this office came from the agricultural sector and was very sensitive to its needs. Even today, after a steady weakening of the communal infrastructures, the agricultural sector accounts for ~2.5% of Israel's gross national product and ~3% of Israel's exports. Its lobby continues to be considered very powerful (Figure 1).

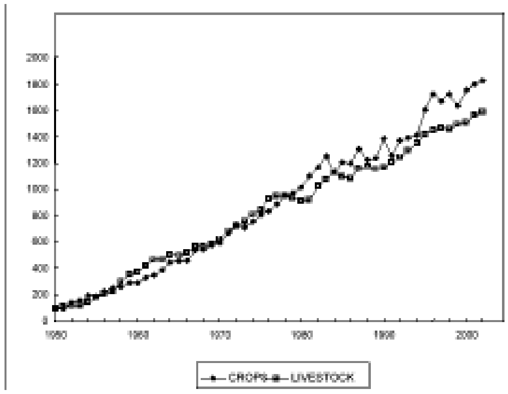

Figure 1: Quality Index of Agricultural Production, Crops and Livestock

Source: Ayal Kimhi, 2004.

The past few decades have seen a softening of state support for agriculture and a decline in the agronomic ideology of yore. Water prices have gradually increased and subsidies for agricultural water have decreased. The Jewish Agency, a Zionist development organization funded by Jewish donors from around the world, built and supported settlements for almost a century, only to discontinue its institutional support for agriculture and new agricultural settlements during the 1990s. Where previous governmental policies made it practically impossible to alter the status of agricultural lands, new flexible policies have allowed many farmers to change the zoning of their lands, or to rent to commercial ventures, producing powerful incentives to cease farming.

Today, the general trend agriculturally is in the direction of economies of scale. To be competitive, farms have had to grow larger. Once, 1.2 hectares of greenhouse was considered enormous, and now four hectares is the standard. Figure 2 confirms the magnitude of the transition in Israel with small family farms in the Moshav villages giving way to larger agri-businesses.

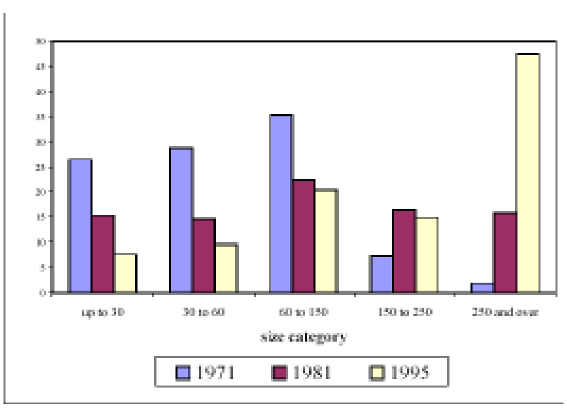

Figure 2: Size Distribution (in dunams; 1 dunam = 0.1 hectare) of active farms among Israeli Moshavim. Source: Ayal Kimhi, 2004.

Agriculture in Israel today

After Israel's independence in 1948, cultivated area was 165,000 ha managed by 400 agricultural communities. Today some 435,000 ha are cultivated by 900 communities. During the same time period Israel's population increased 7-fold, but agricultural production expanded 16 fold. Israel's varied climatic, topographical and soil conditions (subtropical to arid, 400 meters below to 1000 meters above sea level, sand dunes to heavy clay alluvial soils) allow a wide range of agricultural production. Table 1 provides a general breakdown of present production according to land use. As would be expected given the climatic conditions, the majority of agricultural lands are irrigated. Roughly a quarter of agricultural lands are dedicated to orchards, with citrus still comprising a major component of local fruits, even as the groves have migrated south to the northern Negev. Flowers and ornamental plants, intensely raised in greenhouses, have provided revenues far greater than their 1.6% of land space. In general some 1456 hectares of land are utilized as protected screen, net or plastic covered "hot" or "green" house facilities (Figure 3).

Table 1: Agricultural use of land in Israel

Source: Ministry of Agriculture, 2001

	Thousands of Hectares	***% of total lands***
Total `	**382.2**	**100**
- Irrigated crops	**192.3**	**58.6**
- Rain supported crops	**136.9**	**41.4**
Orchards	**84.8**	**25.8**
- Citrus	**25.3**	**7.7**
Vegetables, potatoes, melons,	**55.1**	**16.8**
Flowers, and ornamental plants	**5.2**	**1.6**
Field Crops	**183**	**55.8**
- Cotton	**29**	**8.8**
- *Wheat*	**86**	**26.2**

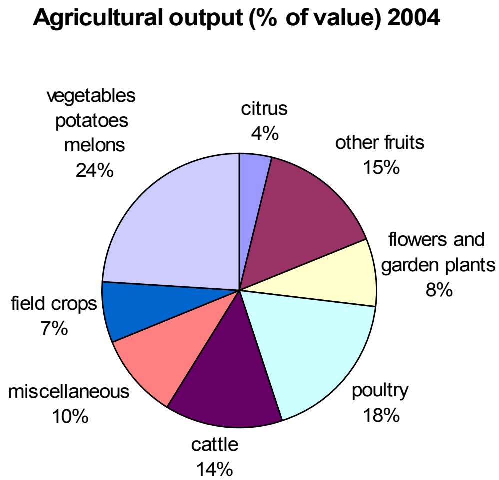

Figure 3. Breakdown of agricultural output by branch. Source: Central Bureau of Statistics

Fruits account for some 280 million dollars in annual exports, two-thirds of which are from citrus. Other fruits cultivated include avocado, kiwi, mango, bananas, dates, apples, pears, cherries, and vineyards for both table and wine grapes. Much of the fruit is harvested out of season for European markets. Approximately 1.7 million tons of fresh vegetables are produced annually, representing 17% of Israel's total agricultural production. Some 110,000 tons of these vegetables, valued at $100 million, are exported each year. Greenhouses today offer controlled conditions for lengthening seasons, increasing yields, and water-saving, spawning prosperous tomato, melon, pepper and other vegetable production. There are 220,000 ha of field crops grown. 160,000 ha of rain fed winter crops (wheat, hay, legumes, safflower) and the remainder is summer crops such as cotton, chickpeas, beans, corn, and groundnuts. The irrigated crops (corn, cotton, groundnuts, potatoes) primarily consume recycled wastewater using drippers and traveling sprinklers. Dairy and beef comprise some 17% of county's total agricultural production. Israel holds the world record for milk production with more than 10,000 kg of 3.3% butterfat milk per cow per year. Poultry for eggs and meat, beef cattle and fish farming are all important in Israel. Over 100 flower varieties are cultivated, many of which are European "summer" varieties grown and exported in winter. Agricultural inputs produced in Israel are valued today at over $2 billion, of which 70% are exported.

Israel produces some 70% of its own food requirements. Grains, oilseeds, meat and fish, sugar, coffee and cocoa are imported. Countering this are $800 million of annual agricultural produce and $600 million of processed foods which are exported. The success of Israeli agriculture since the establishment of the state can be attributed to a number of factors (Tal, 2007). In addition to a commitment to food security, innovative technological development, a steady increase in available work force, the unity of purpose in the agricultural settlement movements, the unconditional political/economic support, and the growing availability of export markets, is found a simply extraordinary record of water development and utilization. (No reference to figure 4)

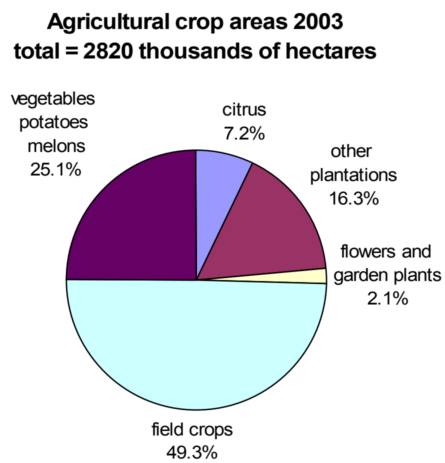

Figure 4. Breakdown of extent of land use of agricultural crops. Source: Central Bureau of Statistics

Water in Israeli agriculture

Water consumption from all sources and for all sectors in Israel has increased from 230×10^6 m^3 (MCM) in 1948 to 1997 MCM in 2002; only 82% of the present amount is annually renewable. The remaining water supplied must be derived by ground water mining, through the use of reclaimed waste water or by desalination. Whereas per capita consumption in the domestic and industrial sectors has remained essentially the same over the years, today, per capita water available for agricultural uses is less than half its volume from the 1960s. Despite the reduction, agricultural production per capita today is more than 150% of that produced 40 years ago, reflecting a threefold increase in water productivity (Kislev 2001).

Fresh water use in agriculture has dropped from 950 MCM in 1998 to around 550 MCM today. Total water to agriculture has been maintained via the utilization of saline and recycled water. In this decade, agricultural production has continued to rise, and agricultural efficiency, whether measured as return per unit water or return per unit land, has steadily increased Of particular significance in Israeli agriculture is the extent that marginal (brackish and recycled) water resources are utilized and the level of water use efficiency that is attained (No reference to figure 5-7)

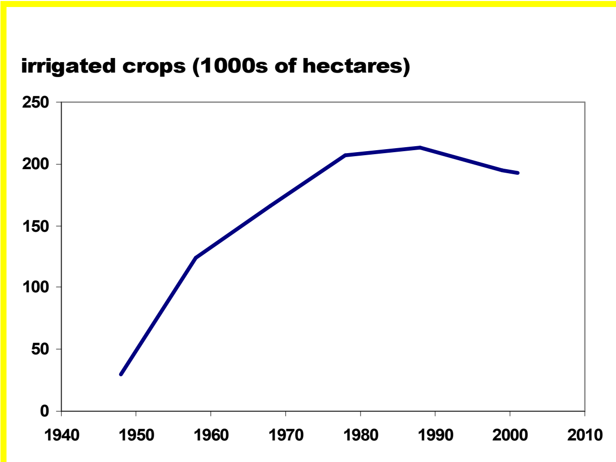

Figure 5. Extent of irrigated land since the establishment of the State of Israel. Source: Central Bureau of Statistics

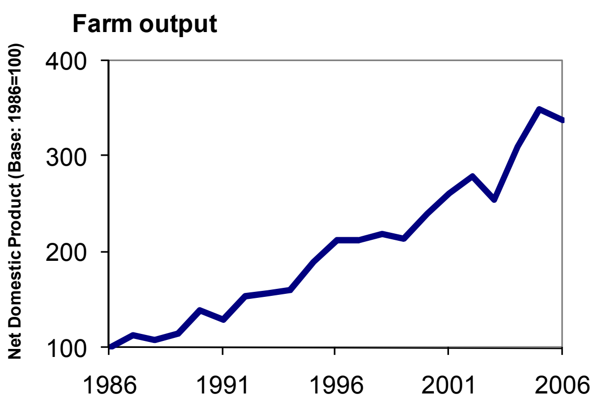

Figure 6. Agricultural production: 1986-2006. Source: Central Bureau of Statistics

Figure 7. Number of people employed in agriculture: 1960-2006. Source: Central Bureau of Statistics

Brackish water

Salts in irrigation water cause stress in crops and reduce yields. Salts introduced with irrigation water accumulate in soils and eventually are leached into groundwater. In spite of this, Israel's agriculture directly uses some 80 MCM of groundwater water that is regarded brackish for irrigation. Salinity in water is commonly quantified by determining its EC or electrical conductivity. Measured in dS/m (desi Semins per meter), EC rises as dissolved salts in water increase. Much of Israel's water has low to moderate salinity. The EC of the National Water Carrier is approximately 0.8 dS/m. Water from brackish wells whose EC reaches more than 2 dS/m is also commonly pumped and used for agriculture. The hottest and driest regions in Israel, including the Negev highlands and the Jordan and Arava Valleys, use the most saline water. In parts of these regions, the best quality water for irrigation has EC values of 2.5 – 3 dS/m and water of up to 5 – 5.5 dS/m is also used.

The combination of high concentrations of salts in water with particularly high crop water demand, resulting from the extreme climate in these regions, essentially creates a situation where salts are being added to the agricultural fields and crops at rates unknown in other parts of the world. Successful agriculture has been developed in the country's arid southlands in spite of this by choosing crops that are relatively salt tolerant and avoiding crops that are particularly sensitive. This is only sustainable through careful irrigation and soil management where salts are maintained lower in the active root zone of the crops and any accumulating salts are leached.

Table 2. Cultivated area, major crops and irrigation water use, 1996 and predicted for 2020.
Source: compiled from Central Planning Authority, Ministry of Agriculture, 1998.

Major Crops	Cultivated Area (ha 000)		Irrigation Water Use MCM/Year					
			Fresh Water		Marginal Sources		Total	
	1996	2020	1996	2020	1996	2020	1996	2020
Tree Plantation	84	82	490		70		560	
Field Crops	233	240	185		205		380	
Vegetables & flowers	43	55	175		25		190	
Fish Ponds	3	3	30		70		100	
Fallow	68	70						
TOTAL	428	430	880	600	378	750	1265	1350
Of which: Irrigated land	183	200						
Dry Land & Fallow	245	230						

Recycled wastewater

Israel has made wastewater recycling a central component of its water management strategy. A master plan presented in 1956 envisioned the ultimate recycling of 150 million cubic meters of sewage, all of which would go to agriculture. Today three times that level is recycled, representing more than 60% of all domestic wastewater produced. Effluents (treated wastewater) today contribute roughly a fifth of Israel's total water supply, and a far higher percentage of the irrigation supply for agriculture. The continued shift from fresh to marginal water use in agricultural production is expected to continue and is incorporated in national planning. Table 2 offers a Ministry of Agriculture projection of future crop area and water use.

Table 3. Source Central Bureau of Statistics

Calendar year	Total water supply	Agricultural supply	Reused wastewater		
	MCM/yr	MCM/yr	MCM/yr	% of total supply	% of supply to agriculture
1965	1329	1075			
1970	1564	1249			
1980	1700	1235	80	4.7	6.5
1990	1804	1216	159	8.8	13.1

2000	1924	1138	269	14.0	23.6
2005	1961	1126	335	17.1	29.8

The supply of water to agriculture continues to decline relative to total supply of water as reflected in Table 3. This makes farmers highly dependent upon a temporal water budget. During drought years, fresh water supply to agriculture is severely diminished, while the flow of wastewater is hardly affected. During the year 1999/2000 Israel faced an extreme drought. In that year, agricultural supply of fresh water was severely reduced but, farmers utilizing reclaimed wastewater continued to receive nearly full amounts of their water supply. In 2008 Israel is facing an additional serious drought situation in which allocations of fresh water are being cut by as much as 50%.

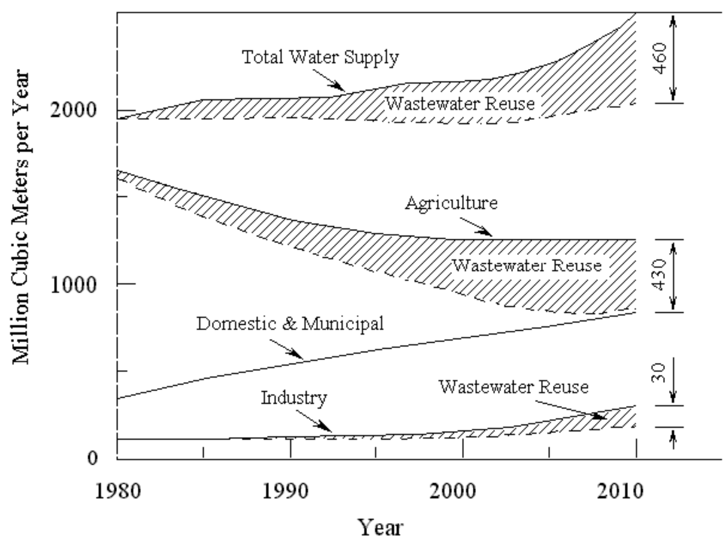

Figure 8. Wastewater reuse as part of the overall water balance (drought years excluded). Source: Shelef 2001

One of the criteria for successful utilization of recycled wastewater is that treatment level is high enough to insure safe use of the effluent. In order for effluent to be the dominant water source for irrigation, water must be treated to a level allowing unlimited use on all crops and on all soils. The Shafdan plant, Israel's largest sanitation facility, is a large-scale project for processing sewage of the Tel-Aviv (Dan region). Wastewater there undergoes biological treatment and then is recharged into aquifers before being pumped and transported to the Negev where the effluent is used in agriculture. The aquifer serves both as a filter in which further purification occurs and as an underground reservoir in which the reclaimed water can be stored seasonally with minimum losses for use in the summer months when agricultural demand is high. About 110 MCM of Shafdan effluents are piped annually to the western Negev for use in irrigation. As is discussed in chapter 7, additional sewage water purification plants are to be built based on this high standard of purification and older plants are to be brought up to this treatment level.

Agricultural water use efficiency

The average requirement of water per unit of land area in Israel has decreased from 8,700 m^3/ha in 1975 to 5,500 m^3/ha in 1995. At the same time agricultural output increased twelve fold, while total water consumption by the sector remained almost constant. Such increased water use efficiency has been accomplished via a number of supporting factors including precision irrigation technology, irrigation water control, and water policy including water allocations, metering and pricing.

Micro-irrigation and fertigation. The wide scale adoption of low volume irrigation systems (e.g., drip, micro-sprinklers) and automation has increased the average efficiency (relative amount of water utilized by crops) to 90% as compared to 64% for furrow irrigation or 75% for sprinklers. Development of drip irrigation technology that allows low flow application of water uniformly throughout agricultural fields and the application of this technology in agricultural water management has been a cornerstone in Israel's advancements in water use efficiency. With drip irrigation, water is supplied when and where crops can utilize it. In addition, a significant advantage of drip irrigation systems lies in their ability to supply nutrients as well as water.

Such fertilizing via the irrigation system (fertigation) allows precision nutrient management and results in increased efficiencies of both fertilizer and water as higher yields are achieved. Today, further irrigation efficiency is being attempted by regulating water application to each individual plant, Root volume water and nutrients can be further controlled by proper irrigation management where soil and crop types are matched with dripper spacing, flow rate and irrigation frequency in order to ultimately achieve maximum plant water uptake and growth with minimum water.

Irrigation Water control. Drip irrigation systems are readily automated. Computers allow real-time response in the operation of the irrigation systems providing precision, reliability and savings in manpower as water application is controlled remotely. Sensors are also used to provide information on soil moisture and plant water status, allowing automatic operation of systems and providing tools that assist to avoid unnecessary excess or deficits in water applications.

Water allocations Water metering and Water pricing. While traditionally subsidized, water prices for agriculture are graded according to water quality. Subsidies to agriculture that were approximately 50% in 1992 decreased to around 20% in 1996 and continue to be decreased. Water charges for various consumers are set by a parliamentary committee. Agricultural water is allocated by quota and purchased at prices that increase as use of the quota increases. The purpose of this price structure is to combine support for agriculture with economic efficiency and encouragement of conservation. Conservation is further encouraged by pricing brackish and recycled water (Table 4) lower than the fresh water and according to level of quality (Kislev 2001, Nativ 2004).

Table 4. Agricultural water prices. Source: Israel Water Authority, 2008. 1 US$ = 3.5 NIS.

Agricultural use	
Fresh water	US$/cubic meter
up to 50% of user's allotment	0.39
Next 30% of users allotment	0.45
rest of amount allocated	0.59
Average	0.45
Tertiary recycled waste water (Shafdan)	0.24
Secondary effluent	0.18
Brackish water	
1.9-2.65 dS/m	0.25
2.65-3.4 dS/m	0.24
3.4-4.1 dS/m	0.21
4.1-4.8 dS/m	0.20
4.8-5.2 dS/m	0.19
>5.2 dS/m	0.17

A critical look at the conflicting roles of agriculture in Israel's water economy

Israel's history suggests that agriculture plays multiple, sometimes conflicting, roles in Israel's water economy. First, irrigation technology and advancements in water use efficiency and agricultural productivity are banners of national pride. Israel is fast to promote its agricultural-water related achievements and even to attempt to export expertise and technology. At the same time, agriculture, as the largest single sector consuming water, is held responsible for water shortages in the country – both ongoing and those occurring periodically due to drought. Irrigation water is the first to be reduced when there is not enough water to go around. In spite of increasing replacement of fresh water with low quality (not fit for drinking) water sources, the use of agriculture as a buffer for water supply management in the country is very hard on the sector that is forced in some years to forfeit up to 50% of normal fresh water allotments. The agricultural sector is also treated as a waste management solution. On the surface, application of wastewater in agricultural fields appears to be both a viable waste disposal solution and beneficial to agriculture, but it does not come without a pretty heavy price.

The salinity of the recycled water (and that of other marginal water sources) causes lower than optimal yields and demands irrigation with substantially greater volumes of water in order to maintain the best possible growing conditions (Ben-Gal et al., 2008; Dudley et al., 2008; Shani et al., 2007). Excess irrigation water for leaching salts not only raises water consumption rates but carries the salts and many other agricultural contaminants (fertilizers, pesticides, herbicides, etc) into and beyond the soil of the fields. Eventually, management for optimized yields using salty water for irrigation causes pollution of soils and groundwater. The policy of waste dumping as an agricultural – environmental solution thus appears to be highly non-sustainable.

Desalination and agriculture

Recently, desalination has begun to be considered economically viable for increasing water supply. In Israel, both incidental and designed use of desalinated water for irrigation have begun to change the water supply portfolio for farmers. Water from the world's largest reverse osmosis desalination plant in Ashkelon is incidentally but largely being supplied farmers in the Northern Negev (Yermiyahu et al., 2007). A number of small to medium size plants designed to desalinate local saline ground water and to serve irrigation needs already exist in the south of Israel and more, larger facilities are currently planned. Irrigation with desalinated water is beneficial as it allows for increased yields and decreased environmental degradation from leaching of salts. In spite of this, desalinated water lacks a number of minerals which are necessary for plant growth and which must be provided in intensively irrigated agriculture. These minerals including calcium, magnesium and sulfur are present in all of Israel's water sources and therefore not commonly added as fertilizers but are removed during the reverse osmosis desalination process.

The missing nutrients can be re-supplied either as fertilizer supplements to the water or soil or, alternatively through blending of the desalinated water with saline water. Each of the options has advantages and disadvantages. Fertilization of the missing nutrients is costly due the basic costs of the chemical additives themselves and requires sophisticated equipment, especially since, due to problems of chemical mineralization and settlement, they cannot be simply added with the regular fertilizers. Blending, on the other hand, is less costly economically and increases the volume of irrigation water but, due to the higher salinity of the blended water, increased leaching rates lead to higher overall water consumption and to elevated pollution of soils and groundwater with salts and other contaminants.

The future

Israel's agricultural future will be faced with a number of essential issues. Many of the issues are water-related and all of these demand regional considerations which will require coordination with the Palestinian Authority and Jordan. A few examples are:

a. Further development of water resources: Desalination, rain augmentation, wastewater treatment and utilization of brackish water;

b. Environmental responsibility: Reduction (preferably elimination) of ground and surface water contamination by salts and agricultural chemicals;

c. Greater Economic Efficiency: Deregulation of the water economy;

d. International Coordination: Respecting the Water rights of the Palestinian population.

Sustainable Water Supply for Agriculture in Palestine

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The geographic and historical area known as Palestine[41] has been inhabited continuously by Palestinians whose forefathers thousands of years ago and even before Christ's time are the Canaanites and Polista tribes of Greece. The Canaanites were the first to plow the earth and cultivate it. The farming of rain-fed olive trees and olive oil production has been the backbone of Palestinian agriculture from the old times of the Roman rule and the more recent Ottoman rule of historical Palestine, which was followed by the British Mandate on Palestine after World War I.[42] This mainly dry-farmed, rain-fed agricultural activity continued with more vigor on the hilly lands of the West Bank even after the Jordanian Administration and the Israel occupation. Similarly, citrus cultivation in the Gaza Strip) expanded under the Egyptian Administration and the Israeli occupation. Jewish settlers, especially from Western Europe and the USA, expanded on the existing irrigated citrus orchards (growing the famous "Jaffa oranges") established by Palestinian farmers before 1948 in the fertile coast of Palestine along the Mediterranean sea and the adjoining plains. Yet, they ventured little into olive cultivation which takes a longer time to produce economically.

Following the aftermath of World War II and Israel's creation, the more fertile Palestinian coastal lands and water resources were controlled by Israel. This became especially true after the 1967 Israeli-Arab war. These disastrous events, from the Palestinian perspective, pushed and squeezed many of these farmers after the 1948 war to the southern part of Palestine to become refugees in the small coastal Gaza Strip. Israeli occupation of the West Bank in 1967 also resulted in the Palestinians being pushed in the

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[41] With the exception of this discussion on the historical perspective, this paper will be focusing on sustainable water for agriculture and related agricultural practices in what is referred to by the UN as the "Occupied Palestinian Territories", or the "West Bank and Gaza Strip", including East Jerusalem, defined by the areas occupied by Israel in 1967, i.e. the areas within the 1949 armistice line.

[42] Over 62 years ago, the author's passion for agriculture was inspired by witnessing his own father diligently planting wild olives in his five hectare hilly land plot near Arrabeh, Jenin, then three years later methodically grafting the young stems with the local Souri (Nabali Baladi) variety and growing them for 15 more years until their production of olive fruits became economically viable. Today, this rainfed orchard produces over four tons of pure organic olive oil from five hectares of that hilly marginal land with no irrigation.

center of the country to the hilly area that is now known as the West Bank truncated from the previous connection with Jordan in the east. Palestinian farmers in the coastal Gaza Strip concentrated on citrus and vegetable production, as they still do. On the other hand, in the West Bank's hills and valleys, Palestinians focused their agricultural activities on rain-fed agriculture as water resources for irrigation were limited and under Israeli military control. Irrigated lands were mostly concentrated in the northwest and northeastern parts of the West Bank, especially the semi-coastal northwest areas near Tulkarem and Qalqilyah.

Of even greater significance in terms of irrigated lands are those at the extreme eastern borders of the West Bank. These Palestinian lands are unique for being near the Jordan River. Their location is unique, being at the lowest elevation on earth, between 50-350 meters below sea level and the warmest area in Palestine. Especially during the winter season these lands serve as a large natural greenhouse.

After the Israeli occupation of the Palestine's coastal irrigated lands, these Palestinian, Jordan Valley lands became the major contributor to irrigated crops including citrus, bananas, and vegetables. Rain-fed agriculture has been and still remains the dominant production mode of the West Bank, mainly for olives, grapes and some fruit trees such as almonds, plums and other stone fruits which were dry-farmed without irrigation. In addition, Palestinians grow field crops and summer vegetables there.

Only about five percent of all the cultivated lands in the West Bank are currently under irrigation and that is mostly, as was indicated, in the semi-coastal and northern areas of the West Bank as well as the Jordan valley areas. Most of these is used for citrus and vegetables with water provided from springs, especially in the Jordan valley around Jericho. The Jordan Valley has become the main source for agricultural production in the winter season while the northern areas serve that role in spring and summer months.

Palestinian development of water resources to support agricultural activity has been stymied in the past by the political situation. Israeli military laws which were issued immediately following the occupation of the West Bank and Gaza Strip in 1967 effectively prevented the drilling of new underground water wells (or expansion of existing ones) in the West Bank, especially for agricultural use. These decrees controlled the pumping of wells inside the Gaza Strip as well, whose water resources were already poor, both in quantity and quality. The Israeli policy led to the water resources of the West Bank hilly mountain aquifer being utilized largely by Israel consumers, leaving Palestinians in the West Bank to mainly depend on rain fed agriculture.

Nearly 80% of the Gaza Strip population is comprised of refugees and/or their offspring. Many left their fields along the coastal plane coastal fields. The existing, inadequate and low quality water resources have been used to grow citrus and to irrigate other crops. The farmers in the West Bank continued to depend in their plant agriculture production on rain-fed trees and crops and in their animal production on sheep and goat milk and meat production using rain-fed wild pasture areas and import of animal feed from Israel.

Even after the establishment of Israel, Palestinian farmers were successful in overcoming the restrictions on free movement and access to lands and water resources by avoiding the most stringent measures of a harsh military occupation on agricultural production. These so-called traditional Palestinian farmers -- as they have been called -- have been able to successfully cultivate olives and produce high quality extra virgin olive oil as well as cash crops such as strawberries, cut flowers, and vegetables for export. When restrictions do not prevent it, as is currently the case for all agricultural exports from Gaza, Palestinian farmers export large quantities of agricultural produce to Israel and to high-end markets in Europe and other countries.

Palestinian farmers have proven to be dynamic and versatile in changing cropping patterns, shifting from one vegetable crop to another, depending on Israeli restrictions and market influences, either existing or anticipated. The extent to which exports are facilitated or restricted to Israel and Jordan is a distinct factor in the cultivation decisions of Palestinian farmers.

<u>Current Land Use and Agricultural Situation in the West Bank and Gaza</u>

Land use patterns in the West Bank and Gaza Strip are constantly changing due to a number of factors, but mainly due to occupation on land use including land confiscation by Israel and the isolation and the

Separation Wall, which is projected to take away over 8.5% of the Palestinian West Bank lands, and a very significant part of the groundwater resources, especially on the northwestern part of the West Bank. This occupation is, of course, in addition to the expected changes of trends in Palestinian land investments with time due in part to political changes.

An analysis of land use in the West Bank and Gaza Strip (Table 1) shows 27% of the land in the West Bank and Gaza is used for agricultural purposes. The Gaza Strip has a higher percentage of 30% showing relative little room for future expansion of agricultural lands in a total area of only 365 km^2. The West Bank on the other hand has only 26% utilization for agricultural purposes. It has a much larger total area of land that can potentially be expanded into for agricultural purposes.

Table 1: Land Use in the WEST BANK and GAZA STRIP 2005 (km^2)[43]

Land Use	**WEST BANK**	**Gaza**	**Total**
Permanent crops and pastures – irrigated	73.3	46.6	119.9
Permanent crops and pastures – rain-red	1079.4	10.0	1089.4
Seasonal crops – irrigated	84.9	32.6	117.5
Seasonal crops – rain-fed	260.5	19.9	280.4
Total agricultural land	**1498.1**	**109.1**	**1607.2**
Forests	88.6	3.2	91.8
Nature reserves	54.4	1.0	55.4
Palestinian built-up area	531.9	53.8	585.7
Jewish settlements	187	0	128.3
Other	3353.7	197.9	3551.6
Grand Total	**5655**	**365**	**6020**

Sources: Agricultural, forests, and natural reserve lands from Palestinian Central Bureau of Statistics (PCBS) Area Statistics, 2005. Built up areas of Jewish settlements from PCBS Israeli Settlements in the Palestinian Territory, Annual Statistical Report, 2006. Palestinian built-up area from PCBS Palestinian Land Survey, 1999-2000.

[43] 1km^2 = 1000 dunams = 100 hectares

The proportion of this land that is irrigated shows a very different profile for agricultural water use in the West Bank versus the Gaza Strip. While only 5-6% (reported as 11% in the above table) of West Bank agricultural land is irrigated, in the Gaza Strip that proportion is 73%. While this is a vast difference in terms of percentage, due to the small area of the Gaza Strip, in practice the total irrigated land in the Gaza Strip is just half of the total irrigated land in the West Bank.

The crop mix that leads to this irrigation profile is illustrated in table 2. One explanation for the low percent of irrigation levels in the West Bank is that the leading crop is olives, which cover over 60% of the agricultural land of the West Bank and which is cultivated almost exclusively as a rain-fed crop. In the Gaza Strip, citrus trees which require irrigation dominate fruit tree cultivation and even the cultivation of various vegetables is done there at much higher irrigation levels than in the West Bank.

Table 2: Key crops in West Bank and Gaza Strip in 2006 (crops with highest ton production)

	Fruit Trees		**Vegetables**		**Field Crops**	
Area	**Crop**	**% of total**	**Crop**	**% of total**	**Crop**	**% of total**
West Bank	**Olive**	**53%**	**Cucumber**	**27%**	**Wheat**	**32%**
	Grape	**19%**	**Tomato**	**26%**	**Dry Onion**	**20%**
	Lemon	**5%**	**Eggplant**	**11%**	**Potato**	**19%**
Gaza Strip	**Orange**	**48%**	**Tomato**	**41%**	**Potato**	**56%**
	Lemon	**11%**	**Cucumber**	**17%**	**Dry Onion**	**18%**
	Guava	**8%**	**Cut flower**	**16%**	**Sweet Potato**	**11%**
Palestinian Territories	**Olive**	**45%**	**Tomato**	**32%**	**Potato**	**32%**
	Grape	**17%**	**Cucumber**	**23%**	**Dry Onion**	**20%**
	Orange	**12%**	**Eggplant**	**9%**	**Wheat**	**19%**

Source: PCBS Agricultural Statistics, 2006.

<u>Land Use Trends - Before & After Occupation</u>

A compilation of research on agricultural land use in the West Bank and Gaza Strip before and after the Israeli occupation (Table 3) shows a decrease in the percent cultivated area in both the West Bank and Gaza Strip. The change over the past 40 years is very dramatic, and may in part be due to different data collection methods over time, but certainly also has factual causes. The expansion of the population, particularly in the Gaza Strip, is due not only to natural population growth but to the continued effects of the absorption of the refugee population from the 1948 war, along with restrictions on access to land, roads, and water resources. Such restrictions are due to settlement expansion and the Israeli military occupation and that would account for the drastic shift in cultivated land areas and type of crops seen between 1964 and 1982. In the West Bank, there is only a minor decrease between 1982 and the present day, but in the Gaza Strip this decrease continues dramatically, and can probably be explained by a combination of high population growth and destruction of citrus crops by Israeli military incursions and neglect of orchards due to water shortages.

Table 3: Cultivated Land in the WEST BANK and GAZA STRIP Before and After the Israeli Occupation (hectares)

Area	Description	1964	1982	2006
West Bank	Total cultivated area (in hectares)	216,870	160,057	149,810
West Bank	Percent cultivated area to the total area of the West Bank (565,500 hectares)	38.35%	28.30%	26.49%
Gaza Strip	Total cultivated area (in hectares)	26,700	16,460	10,910
Gaza Strip	Percent of cultivated area to the total area of the Gaza Strip (36,500 hectares)	73.15%	45.10%	29.89%

Sources: 1964 and 1982 data from Food Security Study (1985) by ASIR for FAO/ ESCWA;

2006 data from PCBS Area Statistics 2006.

The crop mix in the West Bank and Gaza Strip has also changed over time. In the West Bank, there is a clear tendency towards expansion in fruit trees, which are primarily olives, at the expense of field crops and vegetables. In the Gaza Strip, there is an opposite trend, with the area of trees, which in Gaza are primarily citrus, falling against rising areas of vegetables and field crops. (Potatoes and onions are statistically considered as field crops as reported by Palestinian Central Bureau of Statistics). While the reasons for these trends lie somewhat in market issues such as prices, these patterns are also linked to the Israeli occupation measures (Table 4).

.1.2.1.1 Table 4: Type of agricultural crops cultivated before and after occupation in the WEST BANK (in dunams)

Area	**Type of Agriculture**	**1964**	**1982**	**1995**	**2006**
West Bank	Field crops	1,128,100	500,920	525,602	431,538
West Bank	Vegetables	271,130	139,040	136,503	136,429
West Bank	Trees – olive and other	769,270	960,610	1,057,430	1,079,634
Gaza Strip	Field crops	-	-	37,550	64,468
Gaza Strip	Vegetables	-	-	61,249	56,968
Gaza Strip	Trees – orange and other	-	-	86,168	57,059
Palestinian Territories	Field crops	-	-	563,152	496,006
Palestinian Territories	Vegetables	-	-	197,752	192,961
Palestinian Territories	Trees – olive, orange, and other	-	-	1,143,598	1,136,693

Sources: 1964 – 1982 from Food Security Study (1985) by ASIR for FAO/ESCWA; 1999-2006 from PCBS Agricultural Statistics. Note that PCBS statistics classify potatoes and onions as field crops, but not in the Food Security study of ASIR that considers them vegetables.

Olive cultivated areas were and still are on the increase to protect the land from Israeli confiscation, as treeless lands have been more susceptible to confiscation. It is easily observed that the Palestinian farmers have used less area for vegetables due to their vulnerability to extraneous marketing measures by the Israeli occupation authorities and the decrease in the water available for irrigation. In addition to the general water extraction restrictions, the Israeli Government closed the area around the Jordan River (the Zohr) to irrigation by Palestinian farmers. (No reference to table 5)

Table 5: Olive and Olive Oil Production in the West Bank – Various Years

Year	Total Olive trees Production Area (in hectares)	Total Olive Fruits Production (in tons)	Total Olive Oil Production (in tons)
1966	53,700	24,000	4,800
1974	61,800	124,000	24,800
1982	69,200	127,000	25,400
1987	88,000	160,000	35,000
2006	90,000	170,000	34,000

Sources: Assaf's Palestinian reports to the International Olive Oil Council, Madrid, Spain and data of Assaf in the Food Security Study (1985) to FAO/ ESCWA

A closer look at very specific changes in field crops due to Israeli land restrictions are shown below (Table 6). It should be pointed out that the lands cultivated by wheat decreased to less than a third of pre-occupation levels. Considering the recent significant price increases in wheat flour, the continued drop in wheat production has a direct impact on Palestinian income and poverty levels.

Palestinians argue that allowing the planting of field crops in restricted use lands would constitute an important humanitarian gesture. Barley is currently a critical crop due to the skyrocketing prices of animal feed, the majority of which is imported from Israel. The decrease in the production of badly needed barley is continuing and reached critical stages in 2008 making further investments in sheep production very risky nowadays.[44] The several fold decrease in the cultivated land with sesame, due primarily to the labor intensiveness of harvesting it, is also an important matter for Palestinians as

[44] A half-fat tail hybrid sheep (a breed named "Assaf", a hybridization of "Awassi" and "East Friesian" breeds of which it is a hybrid. It was introduced by ASIR in 1981 has proven to be more productive in the production of twins, milk, and meat than the local full-fat tail Awassi breed of sheep and more significantly can do well within the confined sheds on feed concentrates, vetch and wheat hay and thus they are not in need of large wild pasture lands which the Israelis control in the West Bank. This breed has proliferated to more than 20,000 heads now in the West Bank and even a few herds are also in the Gaza Strip.

sesame when it is of the large hardy type as the Palestinian baladi variety is needed for many food products in Palestine particularly tehina (sesame paste) which is manufactured locally with mostly imported sesame seeds.[45]

Table 6: Changes in the Cultivated Area of Wheat, Barley, and Sesame in the West Bank between 1966 and 2006 in hectares

Year	Wheat	Barley	Sesame
1964	65,200	25,000	2,500
1976	33,000	20,000	1,000
1982	20,300	17,100	750
2006	18,008	10,058	399

Source: 1964-1982 from Food Security Study (1985), ASIR,
and the 2006 data from PCBS Agricultural Statistics

It is of interest to note that the Gaza Strip depends mainly on irrigated crops such as citrus and other fruit and more recently strawberries, cut flowers, and vegetables. These crops tend to be sensitive to handling and delays and are highly export based, and not on olives and field crops as in the West Bank which are more dependent on rain-fed agriculture. Thus, as happened in the early months of 2008, the closures of borders and water scarcity made the people in the Gaza Strip more vulnerable to agricultural losses and suffering due to their inability to export to Israel and other countries as well as to the West Bank. Due to water shortages, farmers in the Gaza Strip have begun some expansion of their small olive orchards with some supplemental irrigation. The West Bank produces rain-fed products such as olives and olive oil, and now the valuable jojoba oil as well as cereals, and legumes which tend to have lower returns than vegetables or flowers, but are more stable and can be managed during closures and storage. The distribution of cultivated land in the West Bank by the type of agricultural use emphasizes

[45] Another crop of special interest and relevance in Palestine where Israeli occupation had an opposite effect is that of thyme. In the early 1980s thyme was not cultivated but picked and harvested from the wild thyme bushes in the hills, which rejuvenated the plants and spurred new growth. The Israeli military occupation, citing environmental protection, introduced an odd ban on this practice. In response to this problem, the ASIR Institute developed and distributed thyme seedlings from its greenhouses in the Jenin district and taught interested farmers how to make thyme seedlings from vegetative terminal of vigorous thyme plants and seeds, as there is no law against planting thyme. Thyme seedlings became widely available and thyme is now even used in the various foods in Israel as well as by Palestinians. There are now 1040 dunams of cultivated thyme in the OPT (PCBS Agricultural statistics, 2006).

consideration of the factor of occupation measures in selecting the crops to be cultivated. Of course, vegetables are more susceptible to damage from handling and storage and thus have decreased, and the types of vegetables planted have changed during the occupation.

Water for Agricultural Use in the West Bank and Gaza

It is a matter of fact that one of the major obstacles for good plentiful agriculture production is water. Crops produce several times more when planted under irrigation as compared to rain-fed regimes. Even a desert plant such as jojoba, which is cultivated in both the West Bank and Israel (but only as a rain-fed crop in the West Bank) produces much more with supplementary irrigation, and fertilizers. Furthermore, it is not easy to increase the productivity of rain-fed crops through fertilization as the rains do not come at regular intervals whereas the fertilization of irrigated crops (fertigation) can be managed in terms of amounts and timing.[46]

The irrigation situation in the West Bank and Gaza Strip has been extensively studied and documented. The sources of irrigation water are primarily groundwater wells and secondarily springs (see Table 7 below). As would be expected, the Gaza Strip relies exclusively on wells while the West Bank obtains more than half of its irrigation water from springs.

[46] In fact the term "fertigation" refers to direct application of dissolved fertilizers in liquid form through drip irrigation.

Table 7: Irrigation Water Sources and Amounts Used (Million Cubic Meters)

Area	**.1.2.2 .1.2.3 SprinGaza Strip**	**Underground Wells**	**Total Irrigation Water**
Gaza Strip	0	80.0	80.0
WEST BANK Semi-Coastal Areas	20.7	0.1	20.8
WEST BANK Mountainous Areas	1.7	0	1.7
WEST BANK Wadis Zone	11.7	2.7	14.4
WEST BANK Jordan Valley	35.5	14.3	49.8
Total	49.0	117.7	166.7

Source: Ministry of Agriculture Report, 1999

It should be emphasized that even though there are an abundance of springs and shallow wells in the Jordan Valley, the lands there have a somewhat high salt and sodium concentration and require a lot of water for leaching and washing, whenever water is not restricted for use by the Israeli occupation. Also, as was illustrated in a previous study of the 14 wells of the Arab Development Society (El-Alami) in Jericho, many of the wells have high salinity with higher than acceptable levels of total dissolved solids (TDS), which are suitable for irrigation of only certain field crops, such as alfalfa and barley.

The great inadequacy in the water available in the Gaza Strip forces many of the farmers there to break the law, installing shallow wells “in their backyard. Even though the water available is brackish, it still provides water for immediate use, albeit at the expense of the aquifer. It is estimated that the Gaza Strip has over 2700 unlicensed private shallow wells in addition to the 80 official wells. Controlling the resulting overpumping not only requires laws and regulations, of which there are many on the books, but enforcement of those laws.

Some sea and brackish water desalination projects have begun with success but that is not sufficient to solve the water problems in the Gaza Strip. A basic improvement and continued hydrologically appropriate management of the coastal aquifer is needed. The greatest and most emanate problem to overcome for sustaining agriculture in the Gaza Strip is the use of treated sewage and wastewater for agricultural crops. This requires infrastructure, education, and a whole manageable system.

The use of protected agriculture, particularly greenhouses, for vegetables and other crops has greatly increased and this dramatic change has served to increase productivity and efficiency of water use. To illustrate, Table 8 reports the percent of protected agriculture cultivation in the West Bank. Note the increase by 44% from 1994 to 2006.

Table 8: Area of Protected Cultivation in the West Bank – Various Years

In Dunams	Surface Tunnel	French Tunnel	Greenhouses	Total
1994	8660	262	3858	14774
2006	4777	676	13780	21239

Source: PCBS Agricultural Statistics, 1993/1994 and 2005/2006.

An increase in water conservation, as well as in the efficiency in water extraction and utilization, may also be realized by improving the condition of the Palestinian wells used for irrigation in both the West Bank and Gaza Strip. In the West Bank, a Ministry of Agriculture (MOA) report indicated that five percent of the agricultural wells were drilled before 1950, around 40% between 1951 and 1959, and about 50% between 1960 and 1967. Very few have been drilled since 1967 due to Israeli restrictions, particularly wells for agricultural use.

<u>Potential Irrigatable Land in the West Bank and Gaza Strip</u>

At present, as mentioned previously, the total land area under irrigation in the West Bank is about 5% of cultivated land. There is no precise estimation of the land that could be economically brought under irrigation. Nevertheless, the prevailing view is that the total land area that could possible be irrigated in the West Bank may be as high as 530,000 dunams which can be divided – not by district – but by topographic areas shown as follows (Table 9):

Table 9:

Feasible Irrigatable Land Areas and the Amount of Irrigation Water Required

Topographical Area	Approximate Number of Irrigatable Dunams	Amount of Water Needed to Irrigate the Land (in MCM)
Jordan Valley	100,000	100 MCM
Jenin and Tulkarem	110,000	110 MCM
Hilly Uplands	250,000	108 MCM
Eastern Slopes	70,000	37 MCM
GAZA STRIP	200,000	130 MCM

Source: Ministry of Agriculture Report, 1999.

Reaching these potential levels of irrigated land would first require allowing Palestinian access to agricultural land and water resources in the West Bank, which are restricted by Israeli occupation and settlement expansion. In addition, the estimated irrigatable area could be increased if planting practices emphasized those areas which utilize limited-water resources crops and that have a lower water demand. Spring flow in the West Bank could if properly utilized, be a major source of water for bringing more land under irrigation and for increasing agricultural production.

Many of the conveyance systems for irrigation in the West Bank still consist of dirt canals and/or cement canals that are either in poor condition – or are uncovered. Existing canals need maintenance in order to repair cracks and seepage from the base, and dirt canals need to be replaced with cement canals in order to prohibit infiltration. Utilizing the existing and potential spring flow in a more thorough and efficient manner would benefit the national economy and would allow individual farmers to have a more productive and diversified agriculture while at the same time provide stability to family income and food security.

Many NGOs – both international and national – have begun work on spring development as well as support for protected agriculture using greenhouses and plastic tunnels. The Palestinian Water Authority has also initiated several spring development programs. Items that need either continued or further attention are: maintenance of existing spring structures, development of natural spring sites in order to either maintain, increase, and/or preserve the spring flow for economic purposes; development of more efficient water storage and transfer infrastructure; development and dissemination of information on more efficient irrigation methods, and development of know-how in planting profitable crops that utilize either a minimum amount of water, or water of a lesser quality.

A Water-based Cropping Strategy

Of significance to this discussion is a published proposal to implement a "water-for-peace" strategy for the Jordan River basin countries through a shift in cropping patterns. Parts of this proposal cover the ways and means for sustainable use of water in agriculture. It is pointed out that the countries in the Jordan River Basin (Jordan, Palestine, Israel, Syria, and Lebanon) need to plant productive trees and economic crops which use minimum amounts of water and/or withstand salinity. This is most critical for Palestine whose water resources at present controlled and restricted. Yet even should a peace agreement improve the situation, water supply will be very limited.

The following table 10 shows the different total water needs of some major trees that are grown in the Jordan River Basin countries:

Table 10: Trees Grown in the Jordan River Basin and their Water Sources

Tree Type	Total Water Needs in cubic meters per dunam	Water Source
Bananas	2000	Irrigation
Avocadoes	1700	Irrigation
Mangos	1600	Irrigation
Date palm	1500	Irrigation

Citrus	1200	Irrigation
Guava	1000	Irrigation
FiGaza Strip	480	Rain fed
Olives	400	Rain fed
Apricots	400	Rain fed
Plums	380	Rain fed
Soft shell Almonds	380	Rain fed
Hard shell Almonds	350	Rain fed
Jojoba	300	Rain fed and/or supplemental irrigation
Cactus	150	Rain fed

A similar tabulation is made for some field crops and/or forage crops under rain fed conditions as shown in table 11:

Table 11: Field Crops Grown in the Jordan River Basin and their Water Requirements

Field crops and/or Forage Crops	Rain fall Requirements for Economic Production in total millimeters annually
Corn	600
Watermelon	550
Melons (cantaloupe)	450
Wheat, sorghum, alfalfa	400
Tobacco	400
Chickpeas (garbanzos)	385
Barley	350
Thyme	350
Vetch	325
Lentils	325

Kirsanneh vetch	325
Cumin, anise, blackseed	225

It should also be taken into consideration that certain crops withstand and do well in somewhat saline conditions. The differences in such crops with respect to the saline water and/or soil used for their growth are shown in table 12:

Table 12: Salt-tolerant Crops and Maximum Salinity for Cultivation

Salt Tolerant Crops	Salinity in Total Dissolved Solids (ppm)
Cactus (prickly pears)	2500
Jojoba	2000
Melons	1500
Tomatoes	1200
Alfalfa	1100
Hard seed almonds	800
Olives	800
Citrus	500
Bananas	150

Tomatoes and melons (cantaloupes) were found in experiments by Pasternick in Israel and Egypt to only produce excellent yields with water with a Cl concentrations of 1200-1500 ppm. Moreover, the quality of the product with the saline water was enhanced. The tomatoes had more solids and became tastier, while the melons became sweeter using drip irrigation of that saline water. Better water conservation of irrigation water is realized by growing vegetables under protective covers such as plastic greenhouses, and plastic tunnels than planting these crops in open fields. As mentioned, these dynamics have been internalizedby Palestinian farmers who have increased their protected agriculture areas especially in plastic greenhouses. Those who are unable to have the expensive greenhouses use instead low cost plastic tunnels. The water requirements of several highly consumed crops under open field and greenhouse cultivation are shown in the following table (Table 13).

Table 13: Water Requirements of Some Vegetable Crops under Greenhouse and Open Field Cultivation

Type of Vegetable	Water Needs for Vegetables INSIDE greenhouses, in cubic meters	Water needs for vegetables in open fields
Tomatoes	600	1000
Cucumbers	850	1200
Green beans	750	900
Peppers	600	800
Thyme	300	350

Almonds and jojoba cultivation in Palestine as well as in the other Jordan River Basin countries is an example of a sustainable crop strategy for economic water use in agriculture for the long term. This is reflected in the limited water needs of these nut producing trees as shown above. Jojoba is an evergreen long-lived environmentally friendly tree whose high value oil production compliments olives that are alternative bearing.[47] Almonds have a good market locally and like jojoba, they also require little care. Both of these tree crops do not require large amounts of water to produce economically (Table 14). Their production and care does not require special technology and they can be maintained in the same way as olives.

Table 14: Water Needs and Productivity of Jojoba and Almond Trees

	Jojoba	Almonds
Water needs	Very minimal	Minimal for the hard shell type
Salinity tolerance	Excellent	Fair
Economic returns	Very high from the jojoba oil	Good
Need for insecticides	None	Some
Need for fungicides	None	Some

[47] Putting this approach into practice, the author has planted thus far over 12,000 jojoba trees in several rain-fed hilly areas in the West Bank with 6000 trees 6 kilometers east of the Jordanian international airport.

Percent oil in the nuts	50%	15%
Oil price	20$/liter	11$/kg of nuts
Yield per dunam		
- irrigated -	100 kg/dunam = 50kg oil/ dunam	130 kg/dunam
- rain fed -	40 kg/dunam = 20 kg oil/ dunam	50 kg/ dunam

The water-thrifty crops that were cited here are those that Palestinian farmers should be planting on an expanded scale to replace high water guzzling crops such as bananas and mangoes. Crops that withstand long storage and rough handling without being harmed (such as jojoba nuts (seeds) and oil) have special merits that need to be realized when considering selection or change of cropping patterns. Also crops such as these can help in the alleviation of desertification and unemployment while providing a long sustainable income in arid regions such as that in Palestine.

As a final comment, of course the future use of treated wastewater will contribute to the 'sustainable water supply for agriculture' in Palestine, as well as all countries in the region. However, this aspect was not emphasized in this chapter as it is addressed already in chapter 6. Furthermore, a long timeframe is required for implementation of the appropriate wastewater treatment plants and their associated infrastructure and management systems. To date, there has not been much progress in the Palestinian Authority in expanding wastewater treatment due to the political conditions and the involvement of the Joint Water Committee, which is required to reach decisions by consensus. At times, donor funding was jeopardized due to the failure to obtain required approvals. Without improvement in the political situation, it could be many years before the benefits of treated wastewater irrigation are realized by farmers in the West Bank and Gaza.

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Editors' Summary

Israeli and Palestinian agricultural practices and conditions are in many ways very different. Israel epitomizes an irrigation-driven, high-tech, high-input, high production system, with an increasing utilization of waste water and greenhouses. Palestinian agriculture remains primarily rain-fed, although the percentage of protected agricultural facilities and the general willingness to utilize treated effluents is increasing.

The internal discourse about agriculture in each of the parties, however, has certain similarities. The relative contribution of agriculture to both economies has generally declined over the years and in the long run, will continue to do so. In both communities there are those who believe that the overall water scarcity mandates a steady down-sizing in agricultural production. The growing demand of the predominant urban sector is argued to be more important than maintaining production in a water-intensive agricultural sector, notwithstanding the cultural and heritage significance of farming. Expansion of "Virtual water" – through the increased importation of produce is considered to be inevitable.

Agricultural advocates on both sides, of course are more sanguine. They see an even stronger future for agriculture, based on scientific advancement. They also cite food security, aesthetic/historic/cultural and economic justification for maintaining and even subsidizing the agricultural sector.

Neither internal Israeli nor internal Palestinian critics of present water allocations to agriculture would like to see an elimination of local farming. Most members of the general public believe that it is simply impossible to think about Palestinian or Israeli society without a robust farming sector. Yet critics argue that recycled waste water must continue to become the predominant irrigation source. (Cattle and livestock, for example, will surely continue to require fresh water, although these quantities are trivial compared to the demands of field crops.) Given concerns over social stability, food security, landscape and heritage preservation, like most countries in Europe and the U.S., subsidies for agriculture are widely considered legitimate. They should, however, find expression in areas other than water supply, such as general tax relief for agricultural production, subsidies on farm labor, etc.

Water pricing is another issue which separates the Israeli and the Palestinian agricultural sectors. Today, Palestinian farmers who wish to purchase water for irrigation face a rate of $1.20 ? – a rate far higher than their Israeli counterparts. This creates a clear competitive advantage in what may ultimately be a single market. A final agreement should address this discrepancy, with the advantages of the creation of a regional water market quite evident in the agricultural context.

The fact that many Palestinian farmers rely on private water rights for much of their own production means that reduction of water for the rural sector will not be as smooth as it might be in

Israel. (Nationalization of water sources in Israel occurred fifty years ago and has long since become part of the culture of agricultural regulatory reality.) In the past, Palestinian communities have successfully negotiated the purchasing and transfer of rights for public use and this is expected to continue naturally. The relative profitability of selling water as opposed to using it for rural Palestinians may offer a point departure for the creation of a regional market for water supply. But whether through the pricing of water in an open market or through government allocation, there is a consensus that the amounts of freshwater that will be available *from natural sources* is not going to increase for either farming sector of either side in the foreseeable future. It most likely will decline.

Reductions in water with the objective of down-sizing agriculture has greater social implications today than it did in the recent past for Palestinians. During the Intifadah when movement was restricted and half the population became unemployed, many people returned to subsistence farming. Agriculture offered an economic buffer, temporarily returning its economic significance for many members of the local Palestinian population.

Wastewater and desalinated water are considered to be the inevitable substitutes for future decrease in traditional fresh water supplied to farmers. Israeli farmers in particular have been criticized for exporting crops with high water demands at a time when there is a general shortage. As agricultural has become increasingly supplied by waste water and (and in the future by market-priced desalinated waters) these charges appear less compelling. Desalinated water at their present marginal price level, will be prohibitively expensive for the foreseeable future to be used to irrigate many crops, although there may be some, such as flowers or avocadoes that could afford the higher price for this high quality irrigation source.

While recycled waste water is discussed in greater detail in chapter 7, it can be summarized that without substantial upgrading of present treatment levels and oversight of wastewater recycling, dramatic expansion of present levels is inadvisable. The reuse of poorly treated waste water may exacerbate present salination of ground water and lead to additional health problems. Setting common standards for agricultural recycling could be an important part of a future water agreement in order to enable a transboundary water market for recycled effluents to develop for farm operations.

There is a consensus that due to growing water scarcity, Palestinian and Israeli farmers will need to be even more selective about crops and continue research that will ensure maximum crop water efficiency and salt tolerance. The anticipated precipitation drop associated with future climate change will only heighten the importance of such measures.

Donors can play a key role in supporting the Palestinian agricultural sector, just as Jewish philanthropies historically have boosted Israeli farmers by covering the costs of infrastructure, providing irrigation reservoirs or preparing farmlands. Such assistance (for instance for restoring Palestinian well operation) should be done through the government or a public interest agency, rather given directly through private individuals whose interests may be too narrow to attain optimal economic and social results.

When considering the role of agriculture in a final water agreement a few points are clear. To the extent that water supply will be allocated regionally, agricultural interests, as the largest consumers for both parties, must be consulted. The ultimate role of waste water reuse that is mandated should ensure that high environmental standards are maintained, both to protect ground water, ensure farmers' health and allow for maximum flexibility in crop selection. Food security is an issue of common concern. Yet, as Israel is likely to become increasingly connected to the European market and the future Palestinian state to the Jordanian and Egyptian markets, it is not clear whether the agreement should focus on cooperation in this realm.

8) Desalination

Desalination has not only provided a new source of low-cost water, but also a source of optimism for a technological solution to water quantity controversies. The following chapters assess the present state of local desalination facilities along with the associated concerns of Palestinians and Israelis. The reviews offer a broader context for evaluating the ultimate role of desalinated sea water as a sustainable solution to present water scarcity.

The Coming Age of Desalination for Gaza: Visions, Illusions and Reality

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1. INTRODUCTION

The Gaza Strip is located along the coast of the eastern Mediterranean Sea covering an area of 378 km^2 (UNEP 2005) stretching over a distance of approximately 45 km from Beit Hanoun town in the north to Rafah city in the south, with width of 7-12 km. The Gaza Strip is composed of five governorates, 16 municipalities and 9 local councils. Each municipality has its own water source and a separate distribution system. Water consumption averages 80-100 liters per capita per day. Due to the deteriorating distribution network, water losses are very high, in the range of 35-50%. Growing population and deteriorating water quality has created a growing water "overdraft". The total deficit in domestic water supply for 2005 was more than 7 MCM for the Gaza Strip.

Gaza has no permanent surface fresh water resources. Wadi Gaza located at the middle of the Gaza Strip and, while the wadi has a large catchment in Israel, seasonal rainfall and dams on the eastern side of the border result in only intermittent flow Hence, the primary water resource of the region for potable and agricultural uses is the Coastal Aquifer. The coastal aquifer in the Strip, however, has limited quantities. Its thickness fluctuates from few meters in the east southern area to about 120m in the western areas. Groundwater quality varies according to its depth from ground surface and varies spatially from place to place. Groundwater levels have been in long-term decline and water quality continues to degrade. Induced salt-water intrusion and infiltration from septic tanks have resulted in groundwater quality that exceeds World Health Organization drinking water standards throughout the region. Agricultural production is also adversely affected by salinity, particularly citrus for which the Gaza Strip is famous, resulting in orchards being abandoned in some areas.

.   Existing waste water treatment plants are overloaded, causing pollution and untreated wastewater is discharged to the wadi from the Central Communities with unacceptable environmental impacts. Less than 10 % of the supplied municipal water matches with international standards for domestic purposes. Other diseases linked to water are cancer, diarrhea and methamoglobinia. The incidence of enteric diseases is high, particularly in the refuge camps.

As a result most Gaza residents use various techniques to improve their drinking water or purchase bottled water.   Operating home RO filters is an expensive method and is not affordable for most of the people, The small desalination firms that have emerged are also inherently inefficient, selling relatively expensive drinking water in 20 liter jerry cans.

There is therefore an urgent need to develop new water resources in addition to upgrading and developing the storage and distribution facilities.   The priority in Gaza is to reduce pressure on the aquifer by identifying other sources of fresh water, and to use the non conventional water resources including the seawater desalination.   Large and small scale seawater desalination, is widely perceived among Palestinians as providing a more sustainable water management stratgegy. Critically, it would decrease present dependency on the aquifer. The cost of seawater desalination has decreased in recent years as the technology and its efficiency levels have improved.

Ultimately, desalinated water from Gaza could relieve the water shortages in the West Bank. Yet, to date, no broader supply strategies have been designed beyond local production and supply of desalinated water for Gaza itself. This chapter, therefore, will focus on present plans for desalination in the Gazan context with the understanding that production could eventually be expanded to service all of the Palestinian territories.

2. DESALINATION TECHNIQUES

The need of pure water for drinking purposes is increasing in step with the technological progress. Many places in the Middle East have limited quantities of ground water, or none at all. This means that potable water has to be carried over long distances or to be produces by desalination of seawater.

There is no single best method of desalination that a Palestinian facility should automatically select. A wide variety of desalination technologies effectively remove salts from saline water or extract fresh water from salty water, producing the product stream -- a water stream with a low concentration of salt and the brine or concentrate another with a high concentration of remaining salts. Most of these technologies rely on either distillation or membranes to separate salts from the product water.

Various processes are available for desalinating both brackish and seawater desalination processes. These processes are typically categorized as either thermal o membrane separation systems. Thermal process include multiple effect distillation (MED), multiple stage flash (MSF), mechanical vapor compression (MVE), and some other variations of these three systems. The membrane separation systems include electrodyalisis (EDR) and reverse osmosis (RO).

Seawater desalination by means of reverse osmosis (membrane technology) has been applied for more than 20 years and is emerging as the process of choice for large sea-water facilities. The process is increasingly found in parts of the world where natural ground or surface water for drinking water purposes is only present to a limited extent.

Membrane technology plays a large role in water treatment in general and in RO plants in particular. Advanced technology in manufacturing the membranes has made reverse osmosis the leading and most competitive process for desalinating water when compared to other desalination technologies.

RO uses dynamic pressure to overcome the osmotic pressure of the salt solution, hence causing water-selective permeation from the saline side of a membrane to the freshwater side. Salts are then rejected from the membrane. The RO membranes used are semi-permeable polymeric thin layers, adhering to a thick support layer. Membranes are usually made of cellulose acetates, polyamides, polyimides, and polysulfones. They differ as symmetric, asymmetric, and thin film composite membranes. Membranes are sensitive to changes in pH, small concentrations of oxidized substances like chlorine and chlorine oxides, a wide range of organic materials, and the presence of algae and bacteria. Therefore, careful pretreatment is needed in order to prevent membrane contamination and fouling. Associated measures include pre-filtration to remove suspended solids from feed water;, dosage of acid (hydrochloric or sulfuric) to remove bicarbonate ions, followed by aeration to remove carbon dioxide and filtration by active carbon to remove dissolved organic materials and chlorine compounds. Different anti-scalants are used in order to prevent precipitation of dissolved salts due to increased concentration.

Reverse osmosis is used for both small and large plants, amounting to about 22 percent of the world's larger plants' capacity above 4,000 m^3/day. RO systems can easily be integrated within other thermal desalination technologies, namely hybrid systems for efficient water production.

Electro-Dialysis (ED), or the more modern Reversible Electro-Dialysis (EDR) are another promising alternative process. Here, ions are forced to pass by means of DC electrical power through semi-permeable membranes into concentrated streams. The water leaves behind dilute salt solutions. Its advantages involve the relative insensitivity of the membranes to fouling and the thermodynamic transfer properties. To date, the technique has not yet succeeded a significant market share relative to other processes. Currently, the technique is in use mainly for brackish water desalination and water purification.

` The selection of a desalination process depends on site-specific conditions, including the salt content of the water, economics, and the quality of water needed by the end user, as well as local engineering experience and skills. The technology for desalinating water continues to improve, driven by advances in technology, the need to reduce costs, and commercial competition. The Gaza strip is a special case, where selection of appropriate treatment processes deserves special attention.

Through the launched Water Master Plan and Integrated Aquifer Management Plan, many options and desalination techniques have been considered for use in the Gaza strip as well as the most appropriate location for plant sites. It was concluded that establishing large RO membrane seawater desalination plant is technically feasible and a cost-effective water resource for bringing substantial quantities of new fresh water into the Gaza municipal system.

There were two basic reasons for this decision. Membrane technologies generally have lower capital costs and require less energy than other systems. Other processes for desalination of seawater are less attractive for Gaza. Because of economic reasons, pure distilled water quality is not required. Rather, drinking water with reasonably low turbidity levels (below 700 TDS) can be pumped into the distribution system. Ultimately, selection of the optimal technology was an economic process, allowing gradation in the product quality without requiring mixing to dilute the corrosive effects of distilled water.

The membranes should be properly selected according to the present water analysis, and the quality requirements of the product water. A feasibility study conducted by Metcalf & Eddy concluded that the most economic combination of processes for seawater membrane desalination is to pass RO systems with a seawater membrane in the first pass and nanofiltration membranes in the second pass, in order to be most cost effective and meet product turbidity concentrations of TDS 350 mg/l (CAMP).

5. THE DESALINATION STATUS IN GAZA

The increasing demand for fresh water to supply the Gaza strip has driven decisions about establishing desalination facilities. The desalination market responded in two distinct directions. The first direction involved distribution of pure water for drinking purposes through small scale private brackish desalination plants or slightly larger seawater desalination. The second direction involves implementation of large seawater desalination plants for domestic purposes that can distribute drinking water through the piping system to local customers.

5.1. Drinking Water Desalination Plants

There are several brackish and seawater RO projects/plants in the Gaza Strip varying in output productivity. Desalination of brackish water has already begun in several locations in the Gaza Strip with four major functioning RO desalination plants for brackish water presently operational. Yet, there is a limited quantity of brackish water available for expanded this kind of desalination as shown in the below table and figure.

The chronic scarcity also created a new, smaller market for desalinated water in Gaza through many small scale, private brackish water desalination plants. The number of the registered plants (or registration under process) now reaches around 40 plants, distributing water over all Gaza Strip. These private plants are simply reverse osmosis membranes with a high pressure pump fixed directly to a water well. No pretreatment is included with any clear and no reliable work mechanism is used by the private sector for the quality control monitoring or the marketing of the water.

In addition to the brackish desalination plants it was decided to construct two small seawater desalination plants for drinking purposes, in the Gaza Strip. These plants promise to provide the local Palestinian communities with good quality water for drinking purposes as an emergency solution to alleviate the unsafe supply of domestic water with its very high chloride and nitrate concentration. These plants will be expected to produce water that meet drinking water quality standards. The sources of feed water will be beach wells located close to the sea shore. The treatment process consists of pretreatment (chlorination, coagulation, PH adjustment, sand filtration, safety cartridge filtration, dechlorination), RO process, post treatment and sterilization.

The northern plant one is to be financed through a grant from the French Government. The grant covers the first phase with a capacity of 1250 m3 / day located at the north of Gaza Strip. The second one is to be financed through a grant from the Austrian Government. The first phase involves a capacity of 600 m3 / day with the facility located at the middle area of Gaza Strip.

In all the planned RO desalination plants, the brine water is discarded onto the adjacent grounds and/or into the sea through pipes or tankers delivering the brine water to the sea or to the sewerage network. Brine water which is discharged into the sea shore has a very high concentration of salts and could affect the surrounding environment.

Table 1 below summarizes the status of the brackish and seawater RO desalination plants in the Gaza Strip.

Table 1: Brackish and seawater desalination plants in the Gaza Strip

The Name	**Donors**	**Water source**	**Capacity m^3/h**	**Productivity m^3/h**	**Disposal**
Industrial Zone (the north)	USAID	Brackish well	95	75	Water to be disposed by tankers to the sea
Beit Lahia (the north) Under construction	France	Sea well	60	50	Tanker to the sea
Deir El Balah desalination station	Before Palestinian Authority	Brackish well	78	45	The sea
Deir El Balah	Austria	Sea water	30	20	The sea
Khan Younis, El-Sharqi	Italy	Brackish well	60	50	The sewer system and the sea
Khan Younis, Al-Sa'ad	Italy	Brackish well	80	65	The sewer system and the sea

Figure 1: Location Map of the Gaza Strip and the Desalination Plants (Source?)
(no reference to Figure 1)

5.2. Projected Plans for Large Scale Sea Water Desalination Plants

To improve the domestic municipal water supply system in the Gaza strip an integrated water resources management plan has been developed through USAID funding. According to the plan, the projected water demand in the Gaza strip will dramatically increase and reach about 260 MCM by the year 2020, of which about 180 MCM will be needed for municipal purposes. The associated pressures on the aquifer will cause serious groundwater deterioration and produce a substantial water deficit in Gaza wth water quality and quantity ramifications if significant measures are not immediately implemented. In order to alleviate this crisis and to meet the domestic (municipal) water demand, RO sea water desalination was seen as the most realistic option for Gaza conditions only.

In order to maintain a positive water balance and meaningfully improve the water situation in Gaza, the new large scale seawater RO desalination plants will will need to have a total capacity of 150,000 m^3/day. The implementation of this plant is to take place in the following four phases:

- Phase 1: 60,000 m^3/d
- Phase 2: 60,000 m^3/d
- Phase 3: 20,000 m^3/d
- Phase 4: 10,000 m^3/d

Originally, USAID agreed to finance the design and construction of the first phase of a major RO seawater desalination plant as full donation with a capacity of 60,000 m^3 per day (16 Mgal/day). The Gaza regional North-South water carrier would distribute this high quality water overall Gaza strip. This planned desalination plant could be extended so in the final phase it could reach a capacity of 150,000 m^3 per day in year 2020. The quality of the produced water would match WHO and Palestinian standards for drinking water. The desalination project includes sea intake, outfall, two pumping stations, storage, and 2 km pipeline to Regional Carrier. Some of this infrastructure would be built to meet an eventual capacity of 150,000 m^3/day. However, implementation of these projects were suspended because of the political situation.

5.3. The Environmental Impacts of Anticipated Desalination Plants

Desalination, like any other major industrial process, has environmental impacts that need to be considered and mitigated. The impact includes the effects associated with the construction, operation and effects of withdrawing large quantities of sea and brackish water from an aquifer or seawater and discharging large volumes of highly concentrated brine. Indirect impacts associated with the substantial use of energy must also be considered (Table 2).

Rejected brine is a byproduct resulting from the desalination processes. The brine typically has at least twice the concentration of seawater. Brine water also contains chemicals like anti-scalants, used in pretreatment of the feed water, washing solutions and rejected backwash from the feed water. In large-scale desalination processes, brine discharge detrimentally affects marine life. The high concentration of chemicals in brine water can have a substantial negative effect on marine life.

Table 2: Environmental impact assessment of desalination plants

No.	Category	Impact
1.	Energy: Burning fossil fuels to generate power for desalination plants	Human Health, climate change, agricultural crops, biodiversity and noise level
2.	Land Use: Land use impacts related to the loss of the open seashore for construction of desalination plants	Land degradation and soil contamination
3.	Brine discharge: Rejected brine to the sea contains chemicals like anti-scalants and washing solution.	Brine discharge affects marine life

The constituents of brine water discharged from desalination plants, ultimately depend on the desalination technology used; the quality of the intake water; the quality of water produced; and the pretreatment, cleaning, and RO membrane storage methods used. Distillation plants produce high-quality product water that ranges from 1.0 to 50 mg/l TDS, while RO plants produce product water that ranges from 10 to 500 mg/l TDS. Desalination plants produce liquid wastes that may contain high salt concentrations, chemicals used during de-fouling of plant equipment and pre-treatment and toxic metals. All desalination plants use chlorine or other biocides, to clean pipes and other equipments and sometimes as pre-treatment for the feed-water. As mentioned, at high concentrations these can be hazardous to marine resources,

As part of the specifications for these large RO facilities, a variety of chemicals would have to be neutralized before they could be discharged into water bodies. RO plants use a coagulant (usually ferric chloride), as a part of the pretreatment process to cause particles in feed-water to form larger masses. Ferric chloride is not toxic but may cause a discoloration of the receiving water if discharged. In RO plants, cleaning and storage of the membranes can produce potentially hazardous wastes. The membranes must be cleaned from three to six months depending on feed-water quality and plant operation. The membrane cleaning formulations are usually diluted with alkaline or acid aqueous solutions. These chemicals are also considered toxicity materials when discharged to the sea.

6. CONCLUSION

Seawater Desalination as a source of potable water can relieve Gaza's acute water shortages. Indeed, at present, desalination is considered to be the only realistic and best technological hope for dealing with fresh water scarcity. Desalination would also improve the water quality supplied to the citizens and alleviate the looming water crisis and water deficit in the ground water aquifer underlying the Gaza strip , As Palestinians consider the use of "non conventional" water resources, seawater desalination needs to be a major part of future strategies.

Expanded desalination n the Gaza strip should in no way be considered as a concession of Palestinian water rights and should not affect final stage negotiations in this area. Rather, it should be seen as an emergency solution to alleviate the present water crises and deterioration of groundwater quality. More These plans should be closely evaluated and any adverse environmental impact on the environment in the area prevented through proper mitigation measures to ensure protection of the marine life and the beach area.

The success of a plant's operation is very much dependent on good management. Progressive management encourages staff innovation, continued education, and detailed attention of technical and human resources aspects. Therefore in parallel to the physical implementation of desalination plans. comprehensive training and capacity building programs should be introduced as well as free exchange of information between the management and operating bodies of the desalination plants in the region.

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Desalination in Israel: Status, Prospects, and Contexts

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Overview

Desalination is a marvelous technical feat, separating pure water out of the salt water of seas, brackish aquifers, and wastewater. With membrane technologies improving and the costs of desalinated water dropping, this once exotic water source is fast becoming a mainstay of Israel's water system. The Ashkelon plant, for example, the first of five new facilities planned for Israel, is the largest reverse-osmosis plant in the world, producing 100 million m^3/year, or 15% of total domestic demand. This plant's successful operation has started to shift the perceptions and decisions of the water community in Israel, and some expect Israel to eventually derive half of its potable water from desalination (Dreizin, Tenne, Hoffman, 2008).

Abroad as well, the pricing, technologies, as well as the sophisticated fiscal and institutional structures of private sector involvement in Israel's desalination projects have been regarded with keen interest by water professionals. The Ashkelon plant, for example, was voted "Desalination Plant of the year" in the Global Water Awards of 2006 in Dubai, and the Ashdod plant was awarded the title of "Deal of the Year" for 2007 by *Project Finance*.

Desalination has been a technological holy grail for water-scarce regions, breaking the constraints of local hydrological circumstances with the prospect of a drought-proof independent and predictable supply of "new water." Some form of desalination has been developed in 130 countries, with over 10,000 plants (over a threshold of 100 m^3/day), and an installed capacity growing at 7% a year (Cooley et al, 2006). But desalination must be located as one element within a range of approaches and technologies for managing water needs and provision, with ramified inputs and implications. In this broader context, the creation of new water through desalination in plants such as the Ashkelon plant is distinctive in the degree to which it is, at once, energy intensive, technology-intensive, capital intensive, centralized, and privatized. Similarly, the costs of desalinated water should be contextualized to include the cost of land and negative externalities (the discharge of brine and chemicals, the energy use and air pollutants associated with this, thermal effects and loss of coastal lands) as well as more subtle benefits, such as the value of water reliability and the benefits of relieving water stress, which may reduce political tensions or aquifer depletion.

This chapter gives a brief history of desalination in Israel and an overview of the current scope and consequences of its adoption, and frames these within some larger contextual questions regarding Israel's overall water system. While Israel's aggressive engagement with desalination is one of the more well considered internationally, and more justified than in some other contexts, questions remain about whether this should become the country's central escape path from water-constraints, especially as the world stands at the threshold of an energy-limited and carbon constrained era.

The take-off of desalination in Israel

Israeli decision makers and politicians have long had a soft spot for hard technical fixes, and from the State's early history there was a tradition of visionary thinking and bold execution related to water technologies. By the mid 1950s, Israel had extended irrigation pipes to the Negev desert, was well on its way to a national-scale Water Carrier, and desalination had already been employed for drinking water in Eilat. In the late 1950s the Israeli government was presciently investing a relatively large amount on R&D on desalination, and Israel became an exporter of various desalination technologies (for example the vacuum freezing-vapor compression (the Zarchin process or VFVC) and a battery of other acronymed technologies: SRFD, LT-MVC, LT-TVC, LT-MED. . .).

Despite this, Israel itself employed only a few small reverse osmosis plants in the southern Arava areas, which are not connected to the National Water Carrier, notably a major facility in Eilat. Elsewhere, with prices typically upwards of one dollar/cubic meter of water, desalination was not considered as a feasible option on the supply side with most of the country relying on the Water Carrier and local aquifer utilization through wells. , There was also room for demand-side improvements through increased agricultural water efficiencies and the use of treated wastewater for irrigation.

Given Israel's semi-arid and arid provenance, more sweeping visions of desalination's potential, which had been raised by Ben Gurion, were nurtured by water professionals. As early as 1965 TAHAL, the government (now private) company in charge of water resources planning and development in Israel, had formulated and obtained government adoption in principle for a grand (15 year, $100 million) desalination venture. The enthusiasm of engineers, however, repeatedly encountered the cold feet of decision makers (and, in particular, the Ministry of Finance) when it came to actually getting large desalination ideas funded. For a long time, the Ministry of Finance was convinced that other sources of water must be exploited, and agricultural use reduced (through pricing reform), before the "last resort" of seawater desalination could be considered. Additionally, the powerful agricultural lobby was hesitant about desalination, fearful that this would prompt such a reform, which would de-subsidize their water.

Desalination plans were quiescent for some decades, but by the 1990s several cycles of drought and instances of overpumping accompanied by the steady growth of urban water consumption made the crisis of Israel's water economy salient enough to prompt intensive desalination planning. The Israeli Water Commission embarked on the planning of mega-scale desalination solutions to meet the increasingly painful gaps between supply and demand and prevent further deterioration of groundwater. An intensive planning process was begun, and a Desalination Master Plan was completed in 1997. This was the fruit of a comprehensive examination of various water sources and demand scenarios, of optimal sites for and capacities of desalination plants, and of desalination costs and benefits (both direct and indirect).

The Commission's planners produced a flexible staged "road map" for using these desalination plants to meet needs as they developed. The plan reserved within the National Master Plan 34B sites for eight desalination facilities plus an upgrading of the Eilat facility, which would come on line in an incremental manner, for a total capacity of 775 million m^3/year.

These plans crossed the threshold to execution at the end of the 1990s, with the combination of a sense of crisis, perceived exhaustion of demand-side and reallocation solutions, and an opened window of pricing feasibility. A prolonged drought and increasing urban water demand caused water levels in natural storage reservoirs to fall below their "red lines," notwithstanding meaningful reductions in per capita domestic, agricultural, and industrial uses of water. At the same time, technology advances brought down the price of seawater desalination dramatically. These circumstances led to the approval and budgeting in 1999 of a range of new water projects, including large scale seawater desalination. On April 4, 2002 Government decision 1682 formally adopted a schedule for establishment of four desalination facilities with a combined capacity of 400 million cubic meters / year. The Water Commission was instructed to prepare tenders for the immediate private sector financing, construction, and operation of desalination facilities to provide 200 million m^3. In July 2007 the desalination master plan was updated so that the five coastal plants are projected to provide over 500 MCM by 2013.

These five plants are now in various stages. A BOT (build, operate, and transfer) tender was issued for the most readily available of the Master Plan sites, at Israel's southern coastal town of Ashkelon, and a contract for the production of 50 million m^3/year was signed with the winning consortium. The contracted capacity was doubled to 100 million m^3/year a year later, and in 2003 financial closure was reached and notice to proceed with construction was issued. The facility, which cost $250 million, began operation at 50% capacity in August 2005, and 100% capacity in December of the same year, with proven daily production of 348,000 m^3/day.

In 2002 a 25 year BOO (Build, Own, Operate) concession agreement was signed by the special purpose company Via Maris Desalination, for the provision of 30 million m^3 a year at a facility in *Palmachim* (north of the port city of Ashdod) though a request to double capacity was, reportedly, denied. (In a BOO scheme, as opposed to a BOT, the operator owns the site.) Financial closure on the Palmachim plant was reached effective on January 1, 2005, and began operation in Septmber of 2007. In November 2006, Housing & Construction Holdings Ltd. and IDE Technologies Ltd. (through the special purpose company H_2ID) signed an agreement to build and operate a 100 million m^3/year desalination plant in Hadera for about $389 million, and it is expected to come on line at the end of 2009. A 45 million m^3 plant at Ashdod is now being readied for tender, while the Shafdan 100 million m^3 wastewater desalination plant is under longer term planning. In addition, an additional 125 MCM will be bid for by plant owners-operators by 2015. Figure 6 in chapter 1 provides a graphic description of the anticipated Israeli desalination network.

In addition to this chain of 5 large coastal desalination plants, Mekorot (Israel's national water company) operates 31 small plants, mainly in the south of the country, and maintains an extensive desalination research program on sea (Eilat, Ashdod), brackish (Eilat, Kziot, Neve Zohar), and wastewater (Shafdan). The Mekorot facilities have a strong emphasis on tailoring the RO process to site-specific conditions, and on best use of brackish water sources, which are limited but much cheaper to desalinate than seawater. Similarly, Mekorot is active in research on desalination of wastewater, which has a specific energy cost 1/3 to 1/4 that of seawater, but the technology is less mature and, obviously, faces cultural stigmas when it comes to household use.

Finally, while this is nowadays often couched, perhaps misleadingly, as a project designed to "save the Dead Sea," the Red-Dead canal megaproject whose feasibility is now under review under World Bank sponsorship, was initially conceived, and is still largely, a desalination project. The Harza Group prefeasibility study of 1996 projected fresh water production of 850 MCM/year, with the elevation difference being used to generate 550 MW of electricity, part of which would be used for the desalination plant, and pumping the water back up to consumers in Amman. This project will not be discussed in the chapter, nor will the additional important issue of the possibilities of, promises for, and fate of plans for sharing of desalinated water with the Palestinian Authority.

Environmental and health considerations in Israeli desalination

Since the Mediterranean is commonly regarded as oligotrophic (offering little support for life), some of the desalination impacts that might apply in other contexts (thermal impacts, for example), are seen to be less critical. At the same time, there are still large gaps in knowledge regarding this relatively new scale of operation of desalination technology, so caution is in order. Similarly, large scale desalination for drinking water raises novel regulatory and human health issues both internationally (for example, the WHO), and in Israel (for the Ministry of Health and the Ministry of Environment. Additionally, initial results from Israeli experience with the use of desalinated water for agriculture has shown some surprising, negative results due to the altered elemental profile of water, with implications for water management and a revision of desalination standards (Yermiyahu et al, 2007). Some of these, as well as energy related issues, are listed briefly below.

Energy demands. Energy demands in desalination facilities are mostly for pushing water through the membranes. (In the Ashkelon plant, for example, there are 32 reverse osmosis treatment trains, containing over 40,000 membrane elements.) This process constitutes 30-40% of the water cost. The theoretical minimum amount of energy needed for RO desalination from seawater is around a kilowatt-hour per cubic meter, though even the most efficient actual plants do not drop below about 4 times this theoretical minimum. For example, the Ashkelon plant has a contractual specific energy of 3.9 KWh/m^3, and actual performance was 10-15% below this. In Ashkelon, the facility is to be powered by two redundant sources: a natural dedicated power plant fueled by natural gas located adjacent to the desalination plant, and high voltage linkage to the national electricity grid.

Boron concentrations. While boron is found in very low levels in drinking water (on the order of 0.03 mg/l), it is present at much higher levels (more than two orders of magnitude greater) in sea water (4-7 mg/l). Since boron at these levels can cause reproductive and developmental toxicity in animals as well as effecting crops additional boron removal processes must be added to desalination plants. Israel was forced to address this issue as a result of damage to sensitive crops when the Eilat plant went on line without boron removal. It was the first country to set a boron limit of 0.04 mg/l for the first generation of desalination plants, and stringent limits (lower than WHO standards) were written into the requirements for the current generation of plants recently tendered. At the Ashkelon plant, for example, the Boron Polishing System installed demands 10% of overall plant energy.

Overly pure produced water. Desalinated water is remarkably pure H_20. This is largely a boon, but may also be a hazard in some respects. Reverse osmosis lowers calcium and carbonate concentrations, which make the product water acidic enough to corrode the distribution system. This reduces the useful life of the system, and can also introduce iron and other toxic metals (copper, lead, cadmium, zinc, nickel) into water. Post-treatment of desalinated water with lime or limestone corrects this problem. In addition, since the desalting process largely removes a range of ions normally found in drinking water, and which may have a supplementary dietary role, especially in certain high risk populations, blending or chemical addition may be necessary (Cotruvo, 15). Additional consequences for agriculture of the altered chemical profile of desalinated water have also received wider attention for the first time due to research on Israeli experiences with water from the Ashkelon and Eilat facilities (Yermiyahu,et al, 2007)

Purity of the intake water. Some toxic materials in source water, such as arsenic and small petroleum molecules can pass through RO membranes. Others can be filtered but may compromise the efficiency of the desalination process. For example, during the first 15 months of operation of the Ashkelon plant there was a summer deterioration in seawater quality, most likely from organic load (particularly sewage) from Gaza entering the plant inlet, causing reduction in production. In wastewater desalination, such as that conceived for the Shafdan facility, a broader suite of contaminants may be present, including metals, other chemicals, as well as pharmaceuticals (as mundane as caffeine and as worrying as endocrine disruptors).

Introduced impurities and brine discharge. The RO process can introduce a variety of substances into the discharged water (backwash liquids containing chemicals used to prevent scaling, corrosion, and fouling of the filters, as well as for pretreatment processes), in addition to the intrinsic production of saline brine that is 2-3 times saltier than seawater. In the Ashkelon plant, for example, the most noteable effect observed so far is from ferric sulfate coagulant, which, even at levels of 28 ppm, adds about 450 tons of iron a year to the sea. Even when mixed with the cooling water of the Ashkelon power station, the discharge discolors the sea with a red plume, a situation now being monitored and presumably managed. It is unclear whether this is simply an aesthetic blight or will have more significant effects on the marine environment. While there is still too little known about the marine impacts of discharges from desalination plants, precautionary suggestions to reduce these include use of more environmentally friendly antiscalants, reduction of iron content, pretreatment of brine for nitrogen so as to avoid eutrophication, and the release of organic cleaning solutions.

Microbes. Many microbial organisms, include bacteria, protozoa, and viruses in sea water may be pathogenic. Not all of these are removed by the desalination process. An additional concern are brominated and chlorinated organic byproducts of disinfection.

Social and institutional considerations in Israeli desalination

One of the more valuable aspects of desalination in the Israeli-Palestinian context that is the subject of this volume, is the additional options and loosening of constraint that it affords. Desalination can, at least temporarily relieve, what Professor Hillel Shuval has termed "hydro-hysteria," that is, a fearful inflexibility regarding territorial concessions and the future management of the West Bank because of its criticality as a source of Israeli drinking water. It also may help avoid irreversible overdrawing of aquifers, or other consequential decisions made during a time of hydro-crisis. Thus, even the extra 15% of domestic water now being supplied by desalination is valuable for this buffering—both imaginative and actual.

At the same time, we must consider the lessening of options that desalination might entail. These stem from the fact that, for the foreseeable future, desalination plants will tend to be **large, private, and draw intensively on nonrenewable and, possibly, polluting energy sources.** Large -- because the unit cost of water drops with the size of the plant. Private -- because governments worldwide prefer "off budget" means of building new infrastructure. Drawing on the expertise of the private sector, and the risk profile of desalination projects is well suited to the risk-sharing arrangements of private-public partnerships. (Pankratz reports that every large seawater RO plant in the world over the last 5 years involves some type of public-private partnership; Pankratz, 2005) Energy intensive - because of the inherent demand of the negentropic desalination process, which can only be feasibly met by non-renewable sources in the short and medium term. Thus, desalination ties Israel's future more tightly into dependency on variability in the price of energy and to the incentive structures of the private sector.

Thus, ironically, in creating a stable source of pure water, not subject to the climatic variations of our region, Israel has buffered itself to one source of vulnerability, but exposed itself to several others. With desalination, Israel is increasingly dependent on water quality in the Mediterranean, the terms of decade-long contracts, and, above all, to energy price variability. To the extent that a larger portion of the cost of desalinated water is a variable cost dependent on rising energy costs, the relative advantage of desalination with respect to other forms of water source augmentation with lower variable costs, for the short run, can be expected to decline.

Desalination allows Israel to avoid hydrological constraints now, through a technological solution for meeting the inelastic demands for potable water; but it may introduce future energy constraints, as the world enters an era where limitations in energy supply and carbon emissions reach the forefront of the policy agenda. In such an era, it is unclear whether alternative energy sources (Qiblawey and Banat, 2008) will be able to meet the needs of a locked in desalination-based water economy, making the nuclear powered desalination plants a compelling option; there are certainly historical precedents for nuclear-powered desalination in the thinking of Israeli technologists and politicians.

While the public private partnerships (PPP) at the core of all Israel's large and new desalination facilities offer many opportunities, they also can challenge those concerned with the best use of public monies and with the transfer of assets and public services from public to private hands. For example, while they can allocate financial risks to the sectors best able to accommodate them, and harness expertise for the public good, BOT arrangements can also cloud accountability, avoid current crises by deferring liabilities to the future, and raise costs by introducing an additional layer of profit margins. The water community in Israel must consider these aspects of the shift toward desalination as well.

In short, desalination is changing the profile of Israel's water resources and perceptions of scarcity among government and business interests. Yet, this burgeoning technology must be considered systemically, with an eye to how it facilitates certain trajectories of development of an integrated energy-fiscal-hydrological system over the time horizon of decades.

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Editors' Summary

Desalination has produced considerable "optimism" among water managers. Indeed it changes the terms of what was perceived as a "zero sum game" and offers negotiators much needed flexibility. Ultimately, desalination represents the possibility of forestalling the enormous shortages that have been projected for so long. Desalination serves to diffuse the explosive rhetoric put forward by the so called: "hydro-hysterics" whose grim visions of a thirsty future do little to allow for rational discussion. Surely, the agricultural sector, which for some time has assumed that its fresh water supplies would only dwindle as domestic and industrial water demand grows have reason for relief.

The private sector has proven to be a robust force in promoting this technology, even in the Gaza Strip, where the plants have been funded through private ventures. At the same time, while the price for desalinated water has plummeted, for some time most farm operations will continue to see the cost as prohibitive. Palestinians in particular balk at the price of moving to desalination as the chief source of domestic water supply – even as a growing number pay far higher rates for bottled water whose quality is frequently inferior to the desalinated alternative.

Several concerns need to be addressed before desalination becomes a regional panacea for anticipated shortages. The first is technical. Palestinians are quick to point out that unlike olive trees – desalination plants do not last forever. Like any factory, they require maintenance. For instance, if you stop running a desalination facility for a few days, the membranes in the plant can sustain irreversible damage. In Gaza, for example, fuel supply is unstable and the threat of violence can compromise water production (even as Israel has meticulously attempted to avoid water supply facilities in military actions). During the intifadah, chemicals became unavailable for key aspects of plant operation (e.g., chemical descalants) and desalination facilities collapsed

In the past, Israelis were surprised when Palestinian enthusiasm to receive water from desalination plants was not exceptional. While in Gaza, desalination is considered inevitable and a driver of hydro-independence, proposals to pipe water directly to the West Bank from Israeli Mediterranean coastal plants still are perceived as inferior to the granting of control over ground water resources over which Palestinian control was incontrovertible.

Environmental concerns are also raised which must be addressed. The copious quantities associated with operation of desalination facilities translate into substantial green house gases. For instance, the energy demands of the Ashkelon facility are comparable to those of a city with 45,000 residents.

Ultimately, desalination will play a critical role in relieving the pervasive water scarcity of the two sides. Yet, the water is costly and brings with it environmental costs. It is therefore important that the commitment to water efficiency and conservation in both entities is in no way attenuated as a result of present capabilities for producing fresh water far less expensively than in the past.

9. <u>The Jordan River Basin</u>

The Jordan River Basin includes the tributaries to the Jordan and of course Lake Kinerret (the Sea of Galilee). As the largest single fresh water resource in the area, its administration and protection is central to long-term sustainable water management strategies for the parties in the area. Indeed, the steady decline in sea levels in the Dead Sea is the direct result of present and past policies regarding the Jordan's waters in Israel, Jordan and Syria. The Jordan has been the subject of international negotiation and discussion since the 1950s when U.S. President Eisenhower sent businessman Eric Johnston as his personal emissary to arrange for a modus vivendi in regional water allocation. Although a comprehensive strategy for managing the Jordan River will ultimately require coordination with Lebanon, Syria and Jordan, these two chapters focus on Israeli and Palestinian perspectives on the River Jordan.

Managing the Jordan River Basin: a Palestinian Perspective

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1. Introduction

From the Palestinian perspective, the Jordan River Basin is the most important surface water resource in the region. The river passes through five countries: it has its sources in Lebanon, and Syria and flows through Israeli, Palestinian and Jordanian lands which are all legal riparians with legitimate rights. The West Bank (as part of Palestine) is therefore a watercourse state as its territory is part of an international watercourse. The climate in this part of the West Bank is characterized by hot and extremely dry summer, because of the limited rainfall it receives and the very high evaporation rate that exceeds the rainfall throughout the year to a considerable extent.

Since 1967, Palestinians of the West Bank have not had access to the Jordan River waters. During this period, groundwater resources of the Mountain Aquifer (Western, Northeastern and Eastern) have been utilized extensively by Israeli water managers for their development initiatives along the western side of the Jordan Valley. There are 25 Israeli settlements in the Lower Jordan River Valley, including the Dead Sea area. The total area of these settlements is 13 km2, with a total population of 5,825. These 5,825 people have essentially stopped all Palestinian development in the Lower Jordan River Valley. These 25 Israeli settlements with 5,825 people use about 39 Mcm yearly from 35 wells – for domestic and agricultural purposes. The seemingly unlimited use of water for themselves – and the parallel Israeli restrictions on the Palestinians – has made socio-economic development for the Palestinian majority living in the Jordan Valley nearly impossible.

Most of the Palestinian communities in the Jordan Valley suffer extremely from shortages of safe and reliable water supply for domestic, agricultural, and municipal purposes. The main water source supplying these communities is the limited groundwater which also provides the flow for local wells and springs. In recent years, the groundwater resources in many locations of the Jordan Valley have suffered from serious degradation, reflected in both a substantial decline in water levels and increasing salinity in several production wells. This constitutes a critical obstacle to local development.

The following factors and conditions form the general context for present hydroloogical conditions:

- Due to climate change and reduced precipitation, the rates of recharges appear to be dropping;
- Israel continues to control most of water resources in the area;
- Over-pumping of wells in order to fulfill the high demand for water by agricultural and industrial activities is depleting the aquifer;
- The untreated wastewater of Israeli settlements exacerbates water quality problems;
- Water quality in the Jordan River itself has continued to drop and makes much of the flow unusable.

To respond to these circumstances, greater efforts should be made and attention given to ensuring the reliable development and sustainable management of all water resources in this area. This chapter gives a brief overview on the whole situation of the Jordan Valley area with respect to available water resources, development and management and the Palestinian perspective on appropriate future policies

2. Jordan Valley Water Resources

The Jordan River is not the only water resource that should be available to Palestinians in the Jordan Valley. There are a variety of sources that need to be considered within a comprehensive water management strategy for the area. The water resources in the area of the Jordan valley are comprised of both groundwater resources (wells and springs) and surface water resources (Jordan River and flood water). Groundwater is considered to be the greatest source of available water supply for Palestinians in the area, for extraction via the resulting wells or springs. Groundwater wells are tapping the quaternary aquifer in the Jordan valley, and from shallow, upper and lower aquifers of the hilly blocks. Some springs are tapping Upper aquifer while others are tapping lower aquifer. Other surface water resources are restricted by the limited quantities of seasonal flood water flowing in wadis and the unavailability of reasonable quality water from the Jordan River which has been fully controlled in practice since Israeli occupation since 1967.

2.1 Groundwater Resources

A- Agricultural Wells

Within the Jordan Valley area, there are more than 180 agricultural wells distributed across the Valley, with long-term average annual extraction rate of 9.0 million cubic meters. The majority of these wells are clustered in the Jericho area where there are more than 81 wells. Most of the existing wells in Jordan Valley were drilled before the year of 1967, and therefore should be considered as old wells, characterized by run-down physical conditions and operations, requiring urgent rehabilitation. Indeed, most of the agricultural wells were drilled between 1950 and 1966 with a total depth range from 50 to 200 m deep. Since 1967 very few new wells have been drilled or restored due to a number of constraints by Israeli authorities. It is reported that most wells have clogged screens with high silt accumulation at the bottom. The pumping rates vary between 40 to 80 cubic meters per hour with the pumps operating for about 10-12 hours per day.

B- Spring Water

Springs are the second major source of water supply in the Jordan Valley area. There are 24 springs in Jordan Valley area with long-term average discharge of 45 Mcm/y. Most of these springs are used mainly for irrigation purposes through old open irrigation channels. Noticeable water losses are taken place through these channels with the drop estimated to range from 25 to 30 %.

2.2 Surface Water

A- The Jordan River

The historic natural flow of the river (excluding withdrawal for water supply purposes) is estimated to be about 1470 to 1670 mcm/year. The headwaters of the Jordan River originate in Jabel Asheikh where three tributaries—Al Hasbani, Dan, and Banias—join together in the Hula Valley. The Al Hasbani River originates in Lebanon and its average flow is 160 Mcm/year. The Banias River originates in Syria and its average flow is 160 Mcm/year. The Dan River's average flow is 260 Mcm/year. The Yarmouk River which flows along the border between Syria and Jordan also contributes to the Jordan River. The river ends its journey when it enters the Dead Sea.

The lower part of the Jordan River flows north to south, continuing along the Rift Valley until it reaches its final destination in the Dead Sea. The Jordan River also receives runoff water from wadis along both sides of the river. While the water of the Jordan River has been tapped to some degree for decades, recently, its natural flow has been almost completely diverted. The average estimated discharge of the Jordan River between 1977 and 1987 ranged from 422 to 435 Mcm. The current discharge of the Jordan River into the Dead Sea is estimated to be not more than 50 Mcm/y – less than 5 percent of its natural flow. In practice, the Palestinians do not have access to the surface water flowing into the Jordan River because of upstream diversions by Israel, Jordan and Syria.

The total area of the Jordan River Basin covered by isohyets[48] of over 300 mm is 14847 km^2. Of this area, 1638 km^2 (11%) is within Palestinian territories. Israel is the greatest user of the Jordan River water, abstracting around 54% of the total flow. Israel transfers huge quantities of surface water through the National Water Carrier from Upper Jordan to Negev, equating to 440 Mcm/yr. At the same time, Palestinians have been denied use of the Jordan River water due to the Israeli occupation since the 1967 war. In addition, Jordan uses 22% of the Jordan natural river flow, Syria uses 11%, and Lebanon uses around 0.3%.

In reviewing the different proposals and plans for developing and solving the water conflicts over the Jordan River, the 1956 Johnston Plan still seems the most important one. The plan was prepared by a special emissary of U.S. President Dwight Eisenhower, allocating what was deemed to be an equitable division of the stream to the different riparians. The Johnston plan gives Palestinians rights to 270 mcm/yr of the water in the Jordan River Basin.

Since that time, development of the Jordan River has been, and will continue to be a key factor for overall sustainable development and socio-economic improvement in the region. Therefore, many plans and proposals have been proposed trying to lay down or outline a permanent resolution of the water conflict concerning the waters of the Jordan River. Most of these ideas have failed due to geopolitical circumstances.

B- Flood Water

Floodwater has limited potential as a water resource in the West Bank. Part of this water, (about 30 McM/yr, on the average), flows through the major dry valley beds to the east, towards the Dead Sea. Because of the seasonal nature of the runoff, the modest duration of the runoff, and the topographic conditions, only a small portion of this runoff can be utilized to provide a dependable supply. Moreover, development costs to take advantage of these flows would be very high. Nonetheless, it has been estimated that a quantity of about 11 MCM could be economically developed from these sources through the construction of small dams in some of the major valleys.

[48] An isohyet is a contour of rainfall depth, in this case total annual rainfall

3. Future Water Resources Development and Management

A variety of development and research projects have been identified that are needed to provide for future Palestinian water needs in the Jordan Valley area. (Aliewi and Assaf, 2004). Among these projects are:

- Storage dams or water retention structures on the main wadis of the western bank of the Lower Jordan River Valley;

- Geological studies, and engineering plans that will allow for the rehabilitation and development of major, local springs, including civil works and storage reservoirs;

- Feasibility and technical studies for artificial recharge of the area's aquifers from seasonal runoff or from treated wastewater to enable either seasonal storage or a barrier to prevent salt water intrusion.

  These should include feasibility and technical studies about the use of winter runoff waters collected in flood plain areas, such as Marj Sanour of Jenin District.

- Implementation of pilot projects that demonstrate the potential for artificial recharge and aquifer storage and for recovery of excess surface flows or treated wastewater;

- Hydrological and meteorological monitoring networks, including establishing gauging, monitoring and sampling systems with all necessary equipment and vehicles for water and soil monitoring of the area;

- Seismic and geophysical equipment for geological and water resource assessment studies.

- Research and pilot studies for the use of brackish water in agriculture and industry – and brackish water desalination using renewable energy.

- The West Ghor Canal as a potential future development project that was proposed at Johnston plan of 1955, which is to be built to provide Palestinians with an equitable share of water from the Jordan River, where Palestinian share was estimated at 240Mcm/yr to be used for the development of the Jordan Valley.

In addition, pilot projects for the use of renewable energy (solar and wind) for water extraction and/or distribution have been proposed, along with public awareness campaigns.

There is an immediate need to begin the rehabilitation of existing wells and springs. The rehabilitation process for wells involves replacing or exchanging well pumps with related accessories, construction of guard and well facilities rooms, replacement of diesel engines with modern electrical ones and the electrical and mechanical maintenance work.

The rehabilitation works required to attain optimal utilization of local springs consist of the following activities:

- Cleaning the main sources of the spring;
- Installing protection fencing;
- Constructing delivery infrastructure such as replacing the old conveyance system by piped ones and replacing the old irrigation networks;
- Installing and supplying water tanks and chlorination units; and
- Construction of catchment reservoirs to collect waters flowing from the spring.

There is also a pressing need to development of new wells in the area. The Palestinian Water Authority (PWA) has plans to drill several new production wells near Tubas and Baradala areas in near future for domestic purposes (The existing Tubas well is slowly drying up). For agricultural purposes, several substitute agricultural wells have already been drilled in Jericho area to replace the malfunctioning and abandoned wells.

Table 1 contains the results of a recent study proposing the potential for future development of water resources in the Jordan Valley

Table 1 Future Potential Water Resources in the Study Area

Water Resource	Available Water Volume				
	Existing (2005)	Pilot Term 2007-2009 (3 years)	Short Term 2010-2012 (3 years)	Mid Term 2013-2015 (3 years)	Long Term (After 2016)
	(MCM/yr)	(MCM/yr)	(MCM/yr)	(MCM/yr)	(MCM/yr)
(1) Existing Water Resources					
· Existing Springs	32.10	32.10	32.10	32.10	32.10
· Existing Wells	11.29	11.29	11.29	11.29	11.29
· Mekorot	5.38	5.38	5.38	5.38	5.38
Sub-total (1)	***48.77***	***48.77***	***48.77***	***48.77***	***48.77***
(2) Future Potential Water Resources					
· Spring Canal Improvement			2.39	4.25	11.46
· Well Rehabilitation		0.49	3.53	7.05	10.80
· New Well Development		0.76	0.76	0.76	0.76
· Storm Water Harvesting				0.50	5.50
· Wastewater Reuse		0.63	1.33	2.13	12.50
Sub-total (2)		***1.88*** *(+1.88)*	***8.01*** *(+6.13)*	***14.69*** *(+6.68)*	***41.02*** *(+26.33)*
Grand-total (1)+(2)	***48.77***	***50.65***	***56.78***	***63.46***	***89.79***

Source: JICA Study Team estimate
Note: Further studies on storm water harvesting are required after collecting sufficient data for analysis.
Water resource of Jordan River flow is not included.

The Red-Dead Sea Canal

The decline of the Dead Sea level to 417 mbsl and the shrinking of the surface area of the Dead Sea to 500km2 are serious problems that need to be addressed. At the Johannesburg Environmental Summit in 2002, the Jordanian Minister of Water suggested the construction of a Red-Dead Sea Canal project (the Peace Canal) with the following objectives:

- to protect the Dead Sea from disappearing;
- to desalinate some 850 mcm/yr of seawater;
- to generate 550 megawatts/year of electricity, and
- to develop new tourism and industrial zones.

Most importantly is the fact that this project would provide an inflow into the Dead Sea to compensate for the 'un-natural' reduction of its historic flow.[49]

[49] The primary reason for the shrinking of the Dead Sea and all the parallel environmental and resource ailments is transfer of waters 'out of the Jordan River Basin' into the Negev through the Israeli National Water Carrier and diversion of waters by Jordan for irrigation.

Since the time of the proposal in Johannesburg, the projected total costs of this project has increased and is now estimated to be five billion US dollars, with one billion given as a grant and the remaining amount as a loan. The project would probably take nearly 20 years to fully implement. The project would offer a new source of water and energy, provided that all of its phases are completed.

A pre-feasibility study has been prepared by the Jordanians, and a TOR has been prepared by the World Bank and discussed many times. The study has just begun.

Palestine supports the proposed project of connecting the Red and Dead Seas if and only if Palestine is considered as a full and historic partner and riparian and without any impact on Palestinian water rights in the mountain aquifer basins and the Jordan River before its diversion. The proposed project of connecting the Red and Dead Seas has long term objectives which the Palestinians support as long as Palestinian water rights aresecured, since Palestine is a full riparian within the Dead Sea Basin (30% of the Dead Sea is in Palestinian lands).

Palestine is ready to participate in regional projects that will benefit the countries in the region, but Palestinians will not give up their water rights in the mountain aquifer and in the Jordan River Basin itself. In other words, desalinated water from a Dead Sea Desalination Project will not be considered a substitute for the just water rights of the Palestinian people. Palestinian rights in the Dead Sea Basin should be secured as part of the Jordan River Basin and Palestinian participation in this initiative should not undermine the Palestinian demand to secure its water rights.

4. Final Word

The Jordan River basin is of critical importance to Palestine for economic, cultural and environmental reasons. Palestine is a full riparian in the watershed and will continue to strive for its water rights in the basin. Ultimately, resolution of the present disagreements needs to be based on n international law with the implementation of a comprehensive plan for the Jordan, ensuring equitable access to all parties.

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Managing the Jordan River Basin – an Israeli Perspective

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The Jordan River begins in the northern part of Israel, the southern part of Lebanon and the Golan Heights, where waters flows from springs, melting snow and rain into the upper Jordan and from there into the Kinneret. The Yarmuk River flows through Syria and Jordan, joining the lower Jordan River a few kilometers south of the Kinneret. The river continues flowing south until the Dead Sea and is its major source of water.

The reduction in the water flows in the lower Jordan is a result of increasing extraction of water from the river's various sources over the past 50 years by the four riparian countries. Today the

Lebanese remove some 50 million cubic meters a year (MCM/year) from the Hatzbani and the Wazzani, tributaries of the upper Jordan; the Israelis remove some 400 MCM/year from different points along the upper Jordan and Lake Kinneret, the Syrians remove an additional amount of about 400 MCM/year and the Jordanians remove some 600 MCM/year. The lower Jordan is left with less than 100 MCM/year, more than a billion cubic meters less than its normal natural flow.

The severe reduction in the flow of water down the Jordan has had a major impact on the Dead Sea. At one time there was an annual flow of over one billion cubic meters from the lower Jordan into the Dead Sea. Together with the flow from springs and winter runoff, this equaled the Dead Sea's evaporation rate, and thus the Dead Sea level remained stable for hundreds of years. Reductions in the flow of water into the Dead Sea began in the 1960's, and today the level of the Dead Sea is falling at a rate of approximately one meter per year. Beyond the shrinkage of the Sea, the falling sea level has resulted in other undesirable side effects. Outlet springs have shifted and are in danger of drying up completely. Over two thousand sinkholes have opened up along the shoreline, endangering humans and wildlife alike. The receding shoreline has left water-front tourist facilities far away from the sea, with mudflats separating them from the water.

The reduction in water quantity has been accompanied by a reduction in water quality. The continued reduction in fresh water flows causes progressively higher concentration of pollutants. Partially treated sewage from Tiberias and the smaller settlements in the region is dumped into the river, along with saline spring water diverted around the Kinneret. Water quality tests taken in the area of the river between the Kinneret and the Yarmuk by the Ministry for Environmental Protection have shown the water to be high in e coli bacteria, nitrates and chlorides, preventing usage of the river for fishing, swimming or recreation of any kind. In general, the water quality improves slightly further downstream due to natural filtration processes.

How we reached this stage of serious reduction in water flow and water quality can be found in the story that is presented below, from a legal and administrative standpoint, rather than an ecological one.

Dreams of how to use of the Jordan River go back hundreds of years, but for the most part, these dreams followed an engineer's vision of using the Jordan to its fullest extent for agricultural and domestic use. The major legal interventions occurred at several stages, some during the British mandate period and others after the State of Israel was formed in 1948.

The need for international intervention is quite obvious. For over 100 years, the Middle East has been known for its tensions. Over the years, many have tried to make it a better and safer place to live by attempting, in varying degrees, to resolve the tensions by facilitating cooperation among the various riparian states. As Aaron Wolf quotes in his articles and website, "water is often a bone of contention and conflict but it has rarely been the source of an outright military clash or war." This is true even in the Jordan River.

The Johnston Plan

Although there were spats of military intervention by Israel against Syria when Syria tried to divert portions of the upper Jordan, these spats never blew up into outright war. The region is volatile enough as it is, however, and the international community has always been keen on reducing tension in the area and preventing war by resolving conflicts. The most famous of these interventions and the one most quoted is that of Eric Johnston, who came to the region as an emissary of President Eisenhower in 1953 to try to divide the water sources of the Jordan among the five riparians.

Mr. Johnston used a very unique method of negotiations. He came without political maps, but rather with hydrological ones. He pointed out on the maps where the sources of the water were located, the patterns of flow and the quantities of water available to the riparians. He asked each riparian what their basic water needs were and they all presented a figure which he accepted and jotted down in his notebook as part of his famous water plan. The plan allocated 132 million cubic meters of water for Lebanon, 400 million m^3 for Israel, 720 million m^3 for Jordan and 132 million m^3 for Syria, each one to withdraw water from sources source which were assigned by Mr. Johnston.

The plan was submitted to the Arab League and Israel for approval in 1955. Israel accepted the plan, and although some Arab governments expressed their support, the Arab League rejected it for the same reasons that the Arab League rejected numerous regional plans, including the United Nations 1947 Partition Plan that established an independent State of Israel. Any recognition of a plan would by definition recognize Israel's existence and since this was anathema to the Arab League, there could be no approval of the plan. In spite of its formal rejection, the plan has served as a basis for withdrawals, and during the 1960s and 70s the number of withdrawals even corresponded to Eric Johnston's figures.

In fact, Israel and Jordan worked out their own arrangements for withdrawals even during the period when there were no diplomatic relations between the countries. These negotiations are known as the "Picnic Table Negotiations" because the representatives would meet near the Jordan River at a picnic table to resolve any serious conflicts over water extractions. Although this very pastoral scene of straw hampers and checkered tablecloths was good for reducing conflict, it was obviously bad for the Jordan River. Over time its entire contents were divided up so that as little water as possible reached the Dead Sea. The waters of the Dead Sea, which could not be divided up for agriculture or drinking water use, were therefore considered wasted water. Allowing water to reach the Dead Sea was considered almost sinful. The Jordan River was divided up between Israel and Jordan while Syria continued to withdraw water at a rate enumerated in the Johnston plan.

Present Pumping Dynamics

Water conflicts continue to emerge along the Jordan River even today. For instance, the Lebanese began to withdraw 10 million m^3 water from the Wazzani River in 2002 without first consulting Israel. According to international law standards, this constituted improper behavior and Israel notified several members of the international community. But the withdrawal was allowed because it was small and inconsequential and, of course, consistent with the Johnston Plan formula.

Now that the countries have successfully siphoned off all they could possibly withdraw from the Jordan, the Yarmuk and the Kinneret, they are looking for other ways to capture and utilize more water. It would seem that today's decision makers can only see their own present uses and their own present needs and not the needs of future generations when it comes to taking natural assets. Although the environmental revolution began over 30 years ago with the Stockholm Declaration in 1972, few have internalized the essence of the Declaration when it declared that man is a trustee for nature. It is not for man to reduce nature to its lowest common denominator but rather to use our assets wisely to protect them for future generations.

In fact, modern ecology talks about improving the quality of the environment for future generations, rather than detracting from it. This may sound appropriate in international conventions, but on the ground things are quite different. No country along the Jordan River has ever agreed to set a minimum basic amount of water necessary for life in and along the Jordan River. ”Life” in this context refers to the ecological life of the river, its ecosystems, its attractive flow and the quality of water. In addition, any decision made should take the future of the Dead Sea into consideration, seeing it as one of the real treasures on this earth with its extensive history, unusual location, huge depth and inherently healthy quality of water.

The environmental section of the Israel Jordan peace agreement of 1994 includes protection of natural resources, with specific paragraphs regarding the protection of the Jordan River and the Dead Sea. Its provisions include environmental protection of water resources, agricultural pollution control, nature reserves, protected areas, and ensuring optimal water quality at reasonably usable standards. But no specifics or methods of implementation were included, leaving a nicely dressed document with no party to go to. Concerning water supply issues, however, the agreement is very specific, with the countries agreeing on reciprocal transfers of million of cubic meters of water from one to the other. The treaty created a special commission, known as the Joint Water Committee, which has a mandate to cooperate in the protection of common water sources. Yet to date, Israel and Jordan have not been able to create a roundtable discussion for the protection of the southern Jordan River and the Dead Sea that includes all the relevant parties, and time does not seem to be working in favor of the river. Israel and Jordan have not set up a formal commission to control actions along the Jordan River and to punish violators for withdrawals that are illegal or illegal pollution.

Further exacerbating the situation is the attitude of both countries when it comes to water use. Jordan now demands that the Red-Dead Peace Conduit be carefully reviewed. This involves a project of immense proportions which will have serious ecological effects not only on the Jordan River but on the Dead Sea as well. Jordan and many Israeli supporters want to dig a canal from the Red Sea to a desalination plant at the Dead Sea and pump the drinking water to Amman, the capital of Jordan. The reason for this project, in fact, is not to save the Dead Sea, which is the slogan used to sell the project, but to bring fresh water to Amman so that Jordan doesn’t have to buy it from Turkey, Syria or Israel.

Jordan also has an extremely misguided agricultural policy, where huge amount of water are used for irrigation in the Jordan Valley while people in Amman have little to drink

Towards a Sustainable Orientation

This all leads to the conclusion that people are not looking at the problem from the correct standpoint. We must first look at the assets we have to use and then use them wisely. Second, let us begin thinking demographically. There has to be an end to overpopulation to allow us to enjoy what little is left of the natural assets available. How can a country continue to promote increasing populations when it has gone way beyond the carrying capacity of its water sources? This is true of Israel as well, which continues to promote large families and immigration from other countries. There has to be a realization that in order to enjoy natural assets, they must be preserved and the continued denigration of our water sources will only lead to a continued devaluation in the quality of life not only for humans, but for all life forms. Human existence and quality of life depends on continued functioning of ecosystems.

What has the legal system done to improve the situation? Very little. The Johnston agreement was never signed, and while the Israel-Jordan agreement was signed, it was never fully implemented.

In addition to the above, one cannot conclude this chapter without mentioning the Palestinian Authority and its desire to become an additional riparian of the Jordan River. After the 1967 War, Israel captured territory that was once Jordanian but is now considered part of an entity entitled the Palestinian Authority. This Authority is not yet a state in the sense that it is not yet a country recognized under the United Nations charter, but it is on the way to becoming a country and in the meantime is an authority with its own Prime Minister, Parliament and free elections. However, large portions of the Palestinian Authority are held under Israeli control.

The Authority itself is divided into three regions, A and B, which are mainly under Palestinian control, and C, which is mostly under Israeli control. Huge portions of the areas adjacent to the Jordan River and the Dead Sea are currently under Israel's control, but in the future there will certainly be a great deal of Palestinian input. In addition, Palestinian cities and towns pollute large tributaries which flow into the Jordan River. One would expect a future peace agreement to include measures that will ensure that action is taken to prevent this situation.

Agreements known as the Oslo Accords were signed between Israel and the Palestinian Authority in 1993 through 1995. These agreements describe concepts of water use and misuse. The agreement also creates a Joint Water Commission and a Joint Technical Committee to manage the joint waters. Yet going beyond the agreement has become extremely difficult. Implementation seems to be a word which does not fit into the lexicon of Middle Eastern politics.

How can Israel and the Palestinian Authority improve the quality of the Jordan River? The starting point is opening the channels of communication, followed by creating basin-wide agreements to protect the quality of the streams and rivers flowing into the Jordan. Israel has taken the first step by creating basin authorities along its major streams, but the Palestinian Authority has not, nor do they have any intention of creating such authorities. Palestinian negotiators tend to look at water only from the standpoint of water use and not from the standpoint of natural assets. Therefore, they look at the facility use of water by setting up service companies rather than natural water authorities, divided along political boundaries with little regard to the geography and watersheds.

For example the present proposal on the table calls for the establishment of three water utilities in the West Bank (north, central and south) and one in Gaza, divided along the present political boundaries of the Governorates. In this situation there can be little agreement on the use of the natural flow of water, and therefore both sides seem to be talking, but neither side seems to be listening. Some of the major sources of pollution could easily be repaired by sewage purification works and the water could then be reused in agriculture and then discharged into the Jordan. Yet this has not taken place at the proper rate. A peace agreement should build clear timetables for such measures.

This all leads to a similar conclusion that one would find along any international border with transboundary waters. Countries need to cooperate, to set up joint commissions, to look at water management from an integrated basin level and to implement master plans and action plans for the major water bodies. As long as this does not happen, chapters like this will continue to be written, criticism will be made, but little will be done because politicians like to have their coffee after a meeting about an agreement, but rarely like to question where the water for their coffee comes from.

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Editors' Summary

More pages may have been written about the Jordan River than any other water resource in the world. Such keen interest internationally certainly has little to do with the size of the river which for most of the year naturally is a modest stream. Rather, the historic, spiritual and religious significance gives it a place in the world's imagination that has never been utilized from an economic point of view.

Hence, future agreements over the Jordan have to clearly consider what its optimal role might be as a regional resource. Economically, rather than talking about adding modest amounts of tomatoes to local farmers' yields, it makes more sense to pursue an ambitious tourist initiative that can bring the three riparians of the lower Jordan together. The economic potential of a peaceful Jordan River as a spiritual center, a resort center or even a center for water sports is substantial. But to attract investment and visitors, the river will have to be undergo a considerable makeover.

The first step towards the reclamation of the Jordan River needs to involve water quantity. The Jordan River's present environmental state is the result of de fault policy decisions of Israel, Jordan and Syria who have preferred transfer of water for agricultural or other objectives to preserving the integrity of the stream. This is a policy which can change, today with the emergence of alternative water sources. At a time when the international community is seriously considering a multi-billion dollar project to bring water to the Dead Sea, surely the cost-effective advantages of returning the Jordan River's flow to its natural level should not be overlooked.

Even if a reasonable permanent flow in the river returns some of its basic aesthetic properties, development efforts will not be successful without substantial improvement of water quality. If Baptisms, swimming or participating water sports endanger visitor health due to water contamination, tourist initiatives will ultimately be unsuccessful.

Pollution into the Jordan comes from numerous sources and countries – and its abatement will require intervention in Jordan, Israel, Palestine and Syria. Future management strategies for the stream should involve a basin-wide commission with all the riparians. Just as the "Nile Initiative" has been a locus for international involvement and support, so should the Jordan create a framework that will readily allow for international agencies to provide funding for sustainable, peace-building initiatives. While this might not be possible with Syria at present, surely a Jordanian-Palestinian-Israeli agency to oversee flow, water quality and tourism along the stream makes sense.

12. Gaza's Water Situation

The extremely poor condition of Gaza Strip's ground water resources has characterized its hydrological reality for some time. The massive salination of wells was well-advanced during the period of Egyptian rule and has only grown worse over time. This chapter offers a joint assessment by a leading Palestinian and Israeli hydrologist about the present state of affairs for Gaza and ideas for improving conditions.

The Gaza Water Crisis

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1. Background

Gaza Strip has a small area of about 365 km^2 in a semiarid region. It is one of the highest population densities in the world. One of the main issues facing the Gaza Strip today is water crises, the availability of safe and clean water, where the groundwater is the only water source. Water situation in the Gaza Strip has deteriorated in both quantitative and qualitative aspects. The problem has not been solved due to technical, social and political constraints according to the Palestinian Water Authoritys plans. Groundwater reservoirs with adequate water quality are diminishing rapidly and demand continually exceeds renewable supply. In addition, the Palestinian Water Authority lacks both the technical and financial resources to handle the water crisis on its own.

In the year 2007, the population living over the Gaza Strip reached about 1.45 millions. Most models anticipate that the local population will double in the coming decade or in 15 years. Population growth needs more water quantities to fulfill the needs for domestic and drinking as well as for local agriculture and industry. The annual groundwater abstraction is estimated at 165 MCM, where 85 MCM is used for domestic needs. Due to the low water use efficiency following losses along the water distribution system (55%) , the consumption tare reaches 80-90 liters per capita per day. Water scarcity in terms of quality and quantity all over Gaza Strip has severe negative impacts on the development of the Palestinian economy and on all aspects of people's lives.

Therefore six steps must be taken immediately to address the water issues:

(1) New infrastructure must be developed for efficient municipal water distribution;

(2) New water sources must be introduced;

(3) Water conservation in the domestic and the agriculture sectors must be promoted;

(4) Remediated wastewater reuse should be introduced to the agriculture sector associated with adequate dual water distribution network systems;

(5) Additional water resources by means of seawater and groundwater desalination must be established;

(6) Regional and international cooperation should be upgraded in water issues.

In other words, rehabilitation of distribution networks, establishing water desalination plants, and new wastewater treatment plants are the only feasible options open to Gaza Strip to address the current and the future water crises.

Statement of Need

The Gaza Strip is densely populated (with an average of 2500 inhabitants living within every square kilometer; in some areas even 4300 inhabitants per square kilometer.) The shallow groundwater reservoir underneath Gaza and the southern coastal plain of Israel is a unified cross-border or transboundary hydrological unit, which is already heavily contaminated by anthropogenic impacts and depleted to the level, which leads to massive seawater intrusion. The local coastal aquifer provides the entire water supply to Gaza. In other words, groundwater from the local shallow aquifer is currently the only source of water to both domestic and agricultural sectors. The quality of this groundwater has deteriorated over the years and extensive numbers of wells are being shut-down due to low water quality, which fall below the minimum standards. A supply of high quality water and prevention of soil and groundwater contamination is the most fundamental problem in this semi-arid environment of the Gaza Strip.

The fact that groundwater is available from only a few meters below the surface enabled almost every farmer to dig his own irrigation well. Local villages and the water authority dug relatively deep production wells for local municipalities for combined domestic and agricultural use, which resulted in a dramatic depletion of the water levels, even below sea level, enhancing sea water intrusion.

The rapid deterioration of groundwater quality in the extremely dense populated coastal plain of Gaza is due to uncontrolled pumping from the aquifer, intensive use of agrochemicals, irrigation with treated (and non treated) effluents, and, in some areas, leaking sewage systems that are based on septic tanks or even “free flow” of domestic effluents in open channels or washes. The Gaza shallow aquifer is prone to contamination by the enormous number of septic tanks, infiltration of leaking sewage pipelines and deep percolation of soil-water loaded with fertilizers, pesticides and herbicides from the intensively cultivated land.

The extremely dense population, whose mass family-unit housing covers the land with massive concrete and asphalt, eliminates much of the natural infiltration from rainfall, which decreases the amount of groundwater recharge below 50% of natural levels per urban unit area. Rainfall recharge of the aquifer amounts to about 20%-25% of the rainfall. This varies from 70mm of rainfall recharge per year in the south to 125mm in the north. Gaza's land is characterized by sandy soil which allows fast infiltration and groundwater recharge into the shallow phreatic aquifer. This natural aquifer replenishment is now blocked by concrete houses and asphalt depriving the local groundwater reservoir from its annual fresh water replenishment. The combination of reduced groundwater recharge and massive percolation of polluted water and sea water intrusion has driven most of the Gaza aquifer far below the drinking level standards. In addition, natural replenishment of saline-brackish groundwater originated from the Eocene Aquitard across the eastern border with Israel elevated groundwater salinity along the eastern sections of the Gaza aquifer, precluding irrigation of various crops.

No constructive solution has yet been proposed to salvage the Gaza local water resources besides sea water and saline groundwater desalination. However, a sustainable development of local water resources can not rely solely on desalination. The best long-term water storage in an arid climate is groundwater which must be developed, treated, and protected just as any other precious natural resource would be. Due to groundwater contamination, the local water authority is looking for an "easy and simple" solution by producing "new water" by seawater desalination. Very little has been done so far in this area of local groundwater protection and remediation, and it has long been considered as a "lost" water resource.

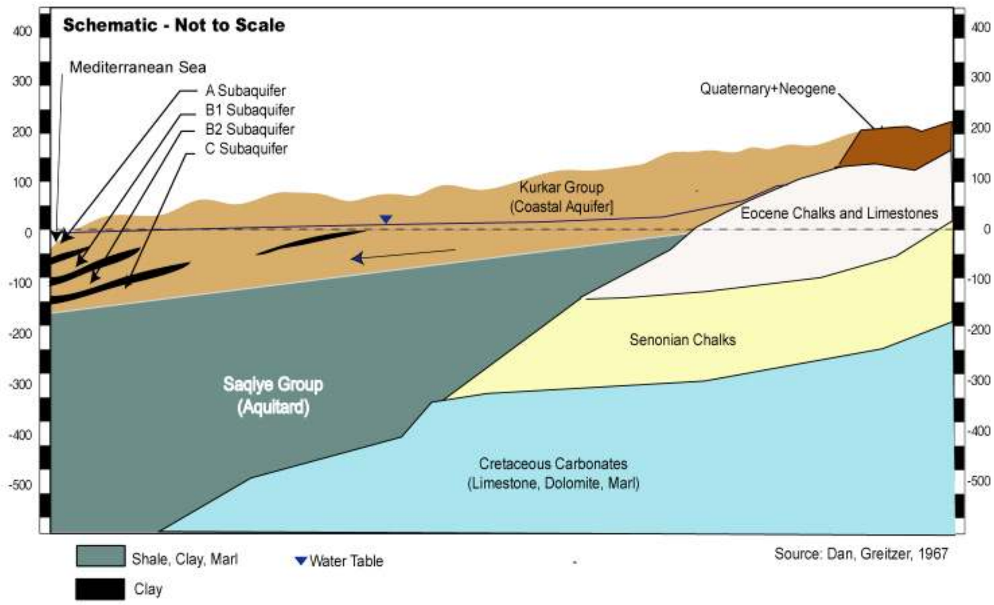
One of the reasons for the current low groundwater storage capacity of this aquifer is because of the massive cover of concrete and asphalt that eliminate groundwater recharge from local rainfall. Subsurface storage of groundwater is by far the most sustainable long-term storage reservoir in arid lands. Therefore, the shallow aquifer of Gaza should not be neglected as a feasible source for future water supply, at least for agriculture and industry end users.

2. Water resources in the Gaza strip

The coastal aquifer of the Gaza Strip is part of a regional groundwater system that extends from the coastal areas of the Northern Sinai in the south to Mount Carmel in the north. The coastal aquifer is generally 10-15 km wide, and its thickness ranges from 0 m in the east to about 200 m at the coastline. The approximate area of the entire aquifer is 2200 km^2, with 365 km^2 beneath the Gaza region. The coastal aquifer consists primarily of Pleistocene age Kurkar Group deposits including calcareous and silty sandstones, silts, clays, unconsolidated sands, and conglomerates. Near the coast, the coastal clays extend about 2-5 km inland, and divide the aquifer sequence into three or four subaquifer units, depending upon location (referred to as subaquifers A, B1, B2, and C). The confinement and the hydraulic separation among the subaquifers depend on the spatial continuity of the coastal clay layers. Towards the east, the clays pinch out and the aquifer is largely unconfined (phreatic).

Within the Gaza Strip, the total thickness of the Kurkar Group is about 100 m at the shore in the south, and about 200 m near Gaza City. At the eastern Gaza border, the saturated thickness is about 60-70 m in the north, and only a few meters in the south near Rafah. Local, perched water conditions exist throughout the Gaza Strip due to the presence of shallow clay layers.

A conceptual geological cross-section of the coastal plain geology is presented in Figure 1. The base of the coastal aquifer is marked by the top of the Saqiya Group, a thick sequence of marls, claystones and shales that slopes towards the sea. The Saqiya Group pinches out about 10-15 km from the shore and in places the coastal aquifer rests directly on Eocene age chalks and limestones. The aquifer transmissivity values are in the range between 700 and 5,000m^2/d .



Under natural conditions, groundwater flow in the Gaza Strip is towards the Mediterranean Sea. However, natural water flow patterns have been significantly disturbed by over pumping and artificial sources of recharge over the past 40 years. Within the Gaza Strip, large cones of depression have formed over substantial areas in the north and south. Water levels are presently below mean sea level, inducing a hydraulic gradient from the Mediterranean towards the major pumping centers and municipal supply wells. Three-dimensional representation of water flow field is presented in Figure 2.

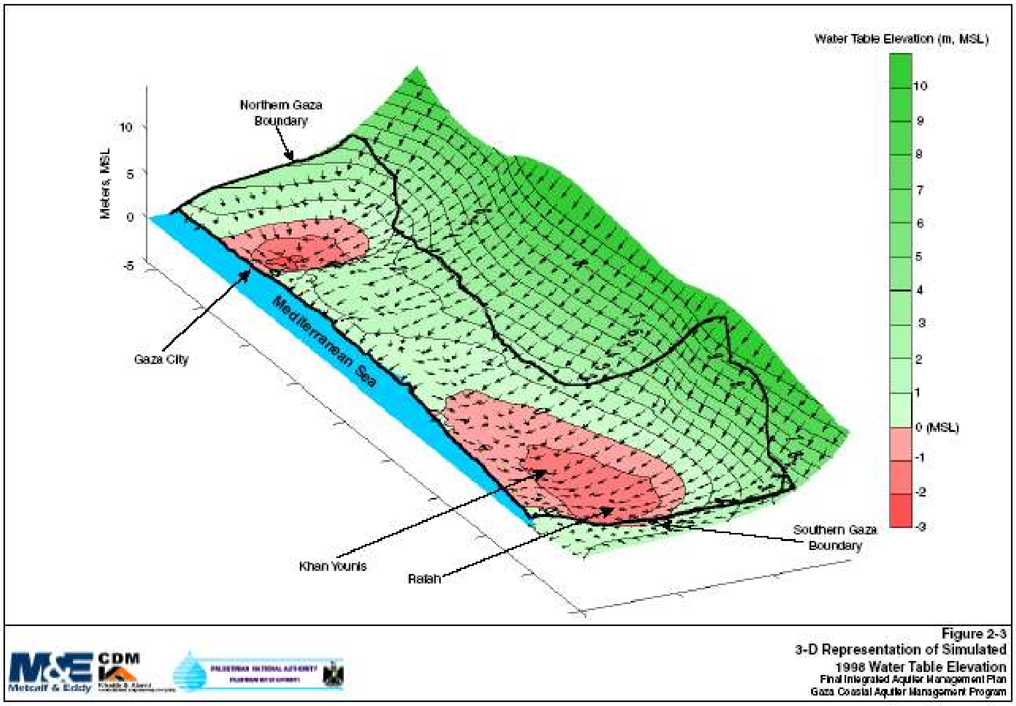


Figure (2): Groundwater flow directions in the Gaza Strip Coastal Aquifer.

Groundwater level

In the year 2005 interpreted water level maps for the Gaza coastal aquifer were developed (Figure 3). In general, the groundwater level is continually decreasing, particularly during the past 10 years, where in areas like Rafah in the south of the Strip water level reaches more than ten meters below sea level, as shown in Figure 4.

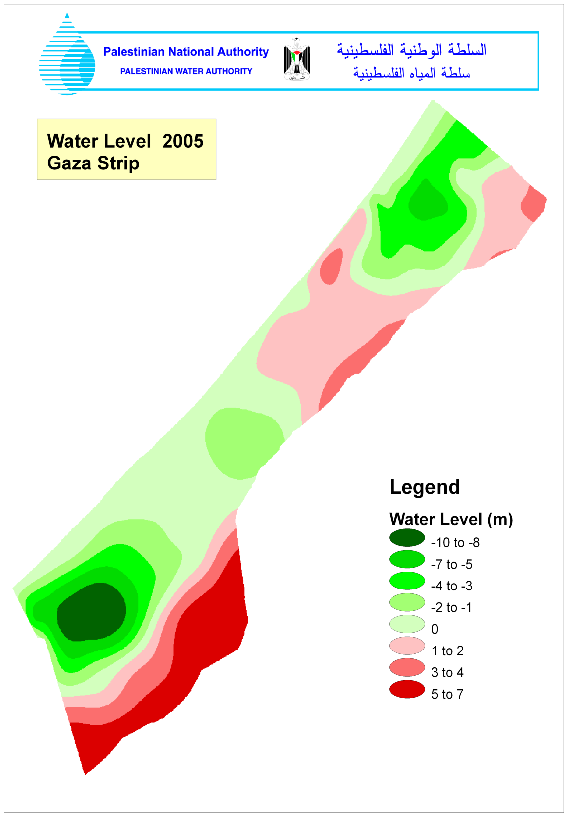


Figure (3) Groundwater level in the Gaza Strip Coastal Aquifer

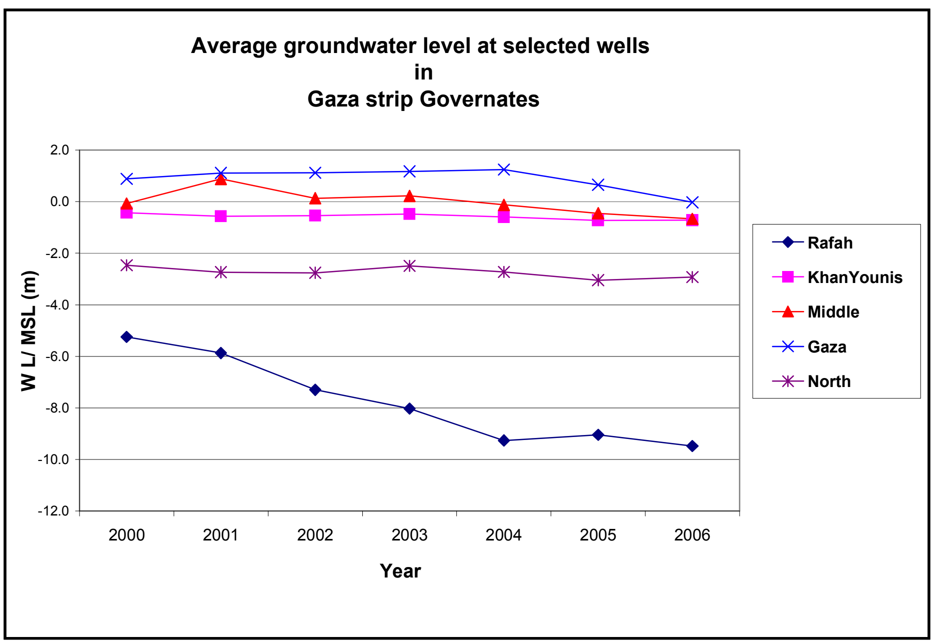


Figure 4. Groundwater level in selected wells across the Gaza Strip.

3. Water Balance of the Gaza Coastal Aquifer

The water balance for the Gaza coastal aquifer was recently assessed. The calculations are based on the estimation of all water inputs and outputs to the regional aquifer system. The components of the current water balance of the Gaza Strip are:

Outflows:

Total groundwater abstraction + Lateral outflow (including natural discharge to the sea).

Inflows:

Effective recharge + lateral inflow + total return flows + saltwater intrusion,

Table 1:- Water Balance in Gaza Strip 2007.

Inflows (MCM/y)			Outflows (MCM/y)		
	Min	Max		min	Max
Effective Rainfall Recharge	40.0	45.0	Municipal Abstraction	75	85
Lateral Inflow from East/ North	15.0	20.0	Agricultural. Abstraction	85	**95**
Deep Percolation from Water System Leaks	10.0	10.0			
Wastewater Return Flows	10	10			
Irrigation Return Flows	15	20			
Total	90	**105**		160	**180**
Net Balance	70-	**75-**			

The 2007 Gaza strip water balance has been simplified and displayed in table 1. The two main components of the water balance are municipal and agricultural well abstraction. The sum of both components exceeds the natural groundwater replenishment (rainfall recharge and lateral inflow from East/ North). In other words, there was a deficit of about 70-75 MCM/year in the year 2007, where the groundwater over pumping has a direct effect on the quality and the quantity of the groundwater. This deficit is expected to grow with the increasing of population in Gaza Strip.

4. Water Demand

Groundwater is the main resource of water in the Gaza Strip. The Strip relies mainly on groundwater to fulfill all local needs. As the natural safe yield of the aquifer is about 40-45 MCM/year, present practices lead to a deficit of 40-45 MCM/year of adequate water quality for domestic supply. In the event that all the returned water from water and wastewater network as well as from irrigation are considered (90-105 MCM/year) in the water balance, total water deficit will still reach about 70-75 MCM/year for both domestic and agricultural use.

Due to the population growth in Gaza Strip, water demand is expected to increase to 260 Mm^3 by the year 2020 (Fig 5). Taking into consideration all returned water in spite of its quality, the total water input will be in the range of 90-105 MCM/years. This will lead to a water deficit of 160-170 MCM by the year 2020 if no management interventions are taken.

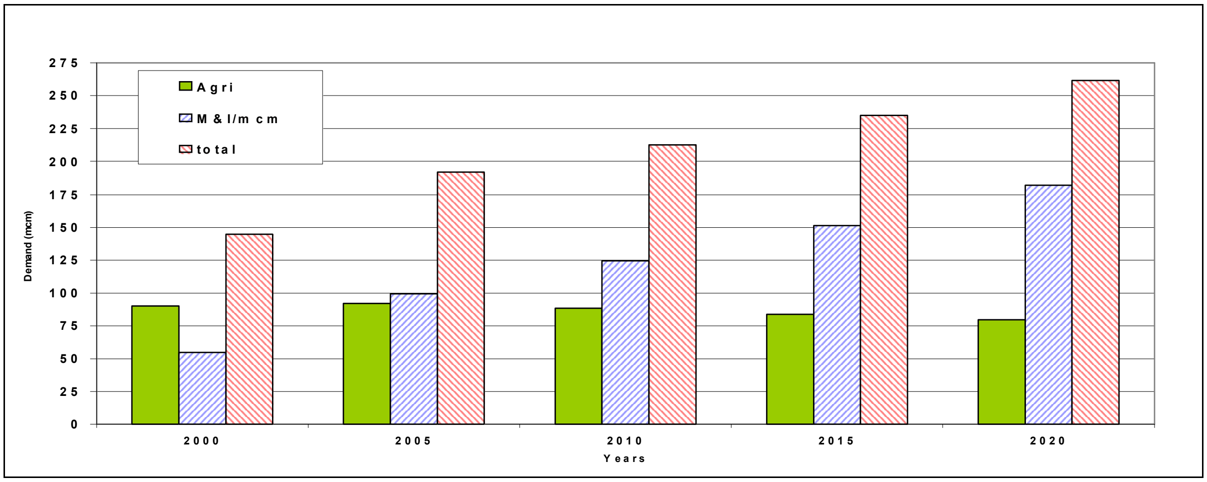


Fig. (5): Present and Future Water Demand in MCMS for Agricultural versus Municipal and Industrial Use in the Gaza Strip

5. Groundwater quality

Large parts of the Gaza Coastal aquifer suffer from a continuous decline of water quality during the past decade. The deterioration is by pollution and increase of salinity. It is mainly due to over-pumping, seepage of raw sewage, extensive use of fertilizers and pesticides in agriculture, solid waste dumps and unchecked industrialization. The primary cause of concern is the unacceptable levels of salinity in the groundwater supply. Excessive and continuous mining of the sub-aquifer units has caused water tables to decline with ensuing seawater intrusion from the Mediterranean. Seawater seepage extends several kilometers in different parts of the Gaza Strip aquifer; the fact that the aquifer slopes toward the sea does not help the situation. Furthermore, greater demand from the rapid population growth will further aggravate the problem. The amount of replenished water is decreasing, while the population is increasing.

The quality of municipal water supply is not acceptable, where the chloride content in most of these wells fluctuates from 300-700 mg/l, which is double the recommended value by the World Health Organization (WHO) which is 250 ppm (Fig. 6).

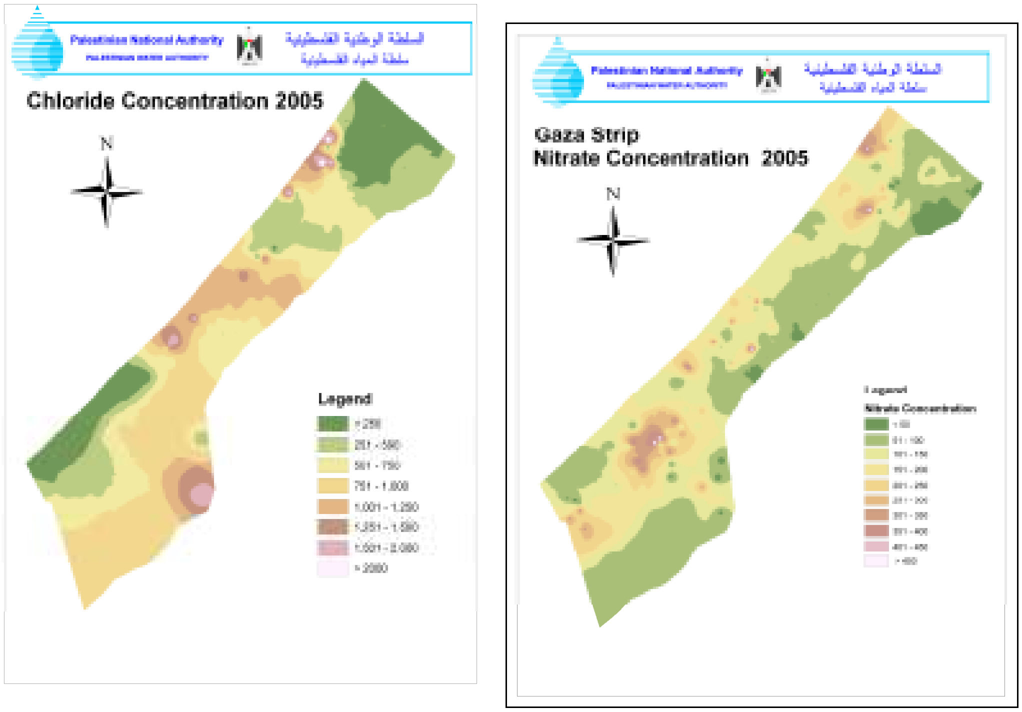


Figure 6: Chloride & Nitrate Concentrations in Drinking Wells (2005)

Nitrate content in the well water is often used as a general indicator of pollution, especially when salinity is low. Nitrate levels in most of the wells are around 100-150 ppm (Fig. 6). This value is three times the recommended value of the World Health Organization, which sets maximum concentrations at only 50 ppm. When considering the other dissolved chemical constituents of domestic water, it can be concluded that most of the public supply wells are not suitable for drinking. The gap between the quality of domestic water in the Gaza Strip and the recommended values by the WHO will increase by time with the natural growth of population and their increasing water demand. Domestic water is also polluted by the leaching of wastewater into the groundwater system with negative impacts on the health of the local residents in general, and children, in particular. This is reflected in the disease profile that the Palestinians presently suffer such as blue baby syndrome, renal failure, cancer, etc.

At present, nitrates concentrations have reached 600 ppm in some areas of the strip like Khanyounis city in the south. Chlorides levels have exceeded 500 ppm, raised to 1000-2000 ppm in the east, mainly due to natural lateral seepage from the neighboring brackish Eocene aquifer encompass the Northern Negev desert. Data from Palestinian Water Authority indicate that chlorides concentration have even hit 3300 ppm in Deir-el-Balah. The pollution problem will only get worse, with chloride concentration increasing by 15-20 ppm annually. Besides eroding the availability of potable water, salinity levels have had a disastrous effect upon agriculture.

6. Strategies for the Future:

There is a pressing need for a new strategy to solve the current and the future water crisis in the Gaza Strip. The strategy and policy guidance should include the following:

1) Priority must be given to domestic users where water quality should be insured to meet, at least, the minimum health requirements.

2) Water conservation policy must be applied to achieve optimum resource use. this will include:

- Minimization of municipal leaks throughout sewage distribution networks rehabilitation;
- Enforcement of laws against illegal connection's and illegal wells;
- Proper metering of water;
- Proposal of better tariffs system which will lead to careful use of water and secure enough revenues to help in the running, maintenance and the water supply system;

3) Reclaimed Wastewater reuse: the waste water is of great potential and can be a major resource in solving the Strip's water problem. Where it has been estimated that more than *half* of the domestic water can be reused when properly treated. The amount can even be elevated providing that **septic tanks** are eliminated and centralized sewage system installed.
4) Selection of crop patterns: Since the area is suffering from water deficit, it is advisable to introduce new crops and adequate species that need less water and are less sensitive to water salinity than the existing crops. The new crops must be economically attractive to the farmers and have good market potential.
5) Rainwater Harvesting: Comprehensive runoff schemes should be developed in order to collect roof rainwater and to catch most of the streets' runoff which otherwise will be partly contaminated with sewage and/or be lost to the sea. The collected water can be used to artificially recharge the aquifer.
6) Enhancement of new water resources: Even by the adaptation of the above policy procedures, the Gaza Strip still will suffer from the water deficit. Beside the above-mentioned acts, the solution

should include desalination of seawater and local salty groundwater. Sea water desalination is more secure and may prove to be financially feasible in the light of improvent in the socioeconomic situation.

7) Intra-regional agreements and institutions for managing water, for sharing supplies, and for avoiding or mitigating quality problems.

7. Proposed projects for regional cooperation

As the water issue has become a political matter, - the development of a final status peace treaty and continued negotiation will contribute to a solution for the Gaza Strip water crisis. Everyone in the region has the right to adequate quantity and quality of water, even as the specifics of such an arrangement have yet to be determined by the parties. The recognition of the rights to water and that most water sources in the region are cross-border resources, illuminates the ongoing need for coordinated water management strategy between all regional water authorities.

As water is a scarce commodity in the region and all parties already suffer from lack of sufficient and adequate quality of water for domestic and agriculture users, the most feasible and immediate solution for Gaza Strip is associated with the production of new water by means of desalination and treatment of effluents.

- **Desalination Plants:** Joint cooperation in establishing seawater desalination plants with high capacity in short (3 to 5 years) and long term (15 to 20 years).

- **Wastewater Treatment Plants:** Develop projects in the wastewater sector and establish reuse of treated wastewater by joint management between the two parties in operation and exchange of experience and information with bilateral and/or regional cooperation.

- **Bilateral and Regional Cooperation:** Cooperation and coordination in the Management of water resources and project through a common committee to mange the water sector (JWC).

- **Cooperation and Exchange of Experience:** Development of scientifically, technical and academic knowledge between the universities and research centers in order to develop common projects in the water sector aiming on increasing research to present new recommendations.

Extending an invitation to the international community and neighboring countries such as Jordan and Egypt to participate in the infrastructure projects such as desalination plant and/or wastewater treatment plants which will help in accelerating the production of additional water for Gaza. It will alsol strengthen the peace process, which may encourage donors to further support the water production and management sectors.

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13. Citizen Involvement

Civil society organisations have begun to focus on building a 'culture of peace' around water issues from the grassroots. Several organizations have taken up the challenge of working across the border over key transboundary issues such as pollution of groundwater and wells, waste-water management, cross-border streams and the management of shared water resources. Given the differences in the political and social make-up between Israel and the Palestinians, civil society organisations focused on water necessarily have different priorities and means to be effective. Whilst Palestinian NGOs necessarily focus on humanitarian and infrastructure development work, Israeli NGOs are more geared towards pollution prevention and habitat protection through advocacy-based and legal approaches. Whilst Palestinian NGOs have a strong focus on water conservation, noticeably little attention is given to addressing water demand issues by the environmental movement in Israel. This chapters considers the range of organizations who are in a position to make important contributions towards developing creative and equitable solutions to regional environmental problems at a time when respective governments are mired in conflict and inaction.

The Role of Civil Society in Addressing Transboundary Water Issues in the Israeli-Palestinian Context

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...And we must show that water resources need not be a source of conflict. Instead, they can be a catalyst for cooperation."

Kofi Annan Secretary General of the United Nations, 2005

Introduction

In an area of conflict where governments have difficulty discussing civil issues of all kinds, it becomes the role of the civil society to become a voice for these concerns and proffer solutions. The urgency of the water crisis developing in the Middle East which is inherently transboundary in nature, and the low level of negotiations between governments at this time, necessarily brings civil society into the spotlight. The ongoing relationship between Israelis and Palestinians working in civil society on water issues can offer an invaluable alternative forum for addressing this crucial public health and environmental issue, where governments are failing.

This article describes the activities of Israeli and Palestinian NGOs and grassroots initiatives focused on water issues. It explores where their activities in their respective societies differ and where they intercept. The article highlights specifically examples of transboundary co-operation: its successes and failures, with a focus on Friends of the Earth Middle East (FoEME)'s Good Water Neighbours program. Lastly, this chapter will look into the future of the water conflict and the role of NGOs in formal decision making. This includes the importance of recognizing the cross-border NGOs as an important player in resolving conflict and fostering solutions.

The Israeli Perspective

Water and civil society in Israel

Water has become a key issue for the environmental movement in Israel over the last decade. All the major environmental organisations include some activities focused on preventing pollution, habitat restoration and raising public awareness about the health of Israel's water courses. This includes the Society for the Protection of Nature in Israel (SPNI) who campaign against the continued degradation of Lake Kinneret; Adam Teva V'Din who have taken legal action to prevent the pollution of the Kishon Stream as well as taking municipalities to court across the country for releasing sewage water into streams; and Sustainable Negev who focus on pollution in the Beersheva stream. One organisation, Zalul, founded in 1999, has as its sole remit to protect Israel's marine and freshwater environment.

Grassroots-led initiatives have also developed to address water issues, for example the 'Citizens for the Environment in the Galilee' who promote activity to prevent pollution of streams with sewage in Jewish and Arab towns in the North of Israel. This work highlights the lack of infrastructure in Arab municipalities within Israel, especially in North and South of the country. The Galilee Society, which campaigns on environmental justice issues for Israel's Arab community, uses this platform to call for equal access to clean water and sewage treatment.

Israeli organisations primarily focus on the environmental and health affects of pollution water courses, with far less energy targeted towards conservation measures. The exception to this is Israel's Green Party who are launching a campaign on the municipal level on water conservation, as well water quality and public health issues. Recently, the SPNI and Israeli multinational engineering and water management company, Tahal, won a tender from the Israeli Water Commission to run a campaign on water conservation, which is now in its pilot stages.

Almost all the organisations mentioned have focused their legal and advocacy efforts solely on pollution in Israel and Israeli polluters, with little analysis on transboundary water issues. The major mechanism for action by Israeli NGOs has been both public awareness campaigns and using legal means to sue the government for inaction. This approach was made possible with a change in the law in the mid-1990s and has been pioneered by Israeli lawyers working primarily through Adam Teva V'Din.

Water and civil society in the Palestinian Territories

The major NGO's focused on water in the Palestinian Territories are the Palestine Hydrology Group (PHG) and the Palestinian Agricultural Relief Committees (PARC), with offices all over the West Bank and Gaza. These organisations both preceded the establishment of the Palestinian Authority in 1994, and were established to do the essential work needed to provide water supply and infrastructure across the West Bank and Gaza Strip in the absence of an over-arching authority at the time. These organisations are responsible to drilling wells as well as providing water for basic needs. Due to Israeli control over much of their water resources, these organisations must deal with Israeli officials on a regular basis. Since these organisations are service providers but have no ultimate decision-making authority, there is subsequently a close but tense relationship with the Palestinian Authority. For example, the Water

Authority has at times applied for projects through the PHG. This tension is heightened by the fact that the Palestinian Authority has little capacity for enforcing regulation, especially true in areas of the West Bank which are still under Israeli control. It is also heightened by the fact that both PARC and PHG are affiliated with left-wing groups, and not Fatah.

The Palestinian Authority is also beholden to the international donors that fund many of the water infrastructure projects. In the aftermath of the Hamas election victory, the situation was complicated by the creation of parallel Fatah and Hamas ministries, and the fact that international donors refused direct aid money to the Palestinian Authority, channelling it instead through NGO's. Fortunately, this situation has mostly been resolved.

Unlike their Israeli counterparts, the acute water scarcity in the Palestinian Territories means that the major work of environmental NGOs has to focus on emergency relief, humanitarian and development issues. This is especially true of organisations that operate in Gaza which also include the XXX (Abed Rabbo), the Environmental Protection Research Institute (Adnan Ad-Shasi?) and Palestinian Centre for Human Rights (PCHR) who have published reports on water issues in Gaza.

A significant problem in the Palestinian Territories is the lack of trained experts and solid research on water availability. Work to rectify this is being carried out by organisations including the Land Research Centre and Applied Research Institute Jerusalem (ARIJ). ARIJ is also a research organisation focused on water demand and supply issues, as well some practical agricultural projects including drilling wells. In terms of advocacy work, the House of Water and Environment, based in Ramallah, a scientific research organisation has worked with Friends of the Earth Middle East to campaign for the protection of the Mountain Aquifer, highlighting pollution from olive mills, tanneries and raw sewage. However, this is not an easy issue to resolve when polluters lack other means of disposing of their waste and the Palestinian Authority does not prioritise the enforcement of environmental regulations. In general, safeguarding water courses is considered to be the role of the authorities and not the responsibility of civil society.

Whilst civil society organisations can lobby the Palestinian Authority to take action, unlike in Israel there is little scope for NGO's to take legal action against either the Palestinian Authority or polluting companies. Most Palestinian NGOs are unaware of this course of action, with considerable debate as to whether this is, in fact, technically possible. In any case, with no precedent this would be an unlikely course of action for a Palestinian environmental NGO.

Thus whilst Israeli NGO's often find themselves both funded by and confronting the Israeli government on water issues, Palestinian NGOs often find themselves simply replacing the government where service provision is lacking, funded by international funding sources and development agencies.

Israeli- Palestinian Co-operation on transboundary water issues

In the wake of the Oslo Agreement, funding became available for joint work on environmental issues, including water. During this optimistic period, the idea of linking environment to peace-building and mutual tolerance as a rallying call for both Israelis and Palestinians became highly attractive.

As a result, several joint organisations with both Israeli and Palestinian leadership, developed in the immediate afterglow of Oslo focused on environmental issues, including some of the largest and best-funded NGOs in the Palestinian Territories. Friends of the Earth Middle East, then known as EcoPeace, was established in 1994 as was the Palestinian-Israeli Environmental Secretariat (PIES) which was formed in 1997 as a project of the Palestine Council on Health (PCH) and the Israel Economic Cooperation Forum, both post-Oslo transition-era institutions. The focus of the latter organisation included providing a forum for joint work, working with industry, and a means to transfer expertise and technical skills to the Palestinian environmental community from Israel.

Another joint initiative at this time came from a well-established joint organisation, the Israeli Palestinian Centre for Research and Information (IPCRI), an organisation founded in 1988 in the worst days of the first Intifada. In 1992, IPCRI founded its Water and Environment programme and hosted a series of joint discussions on 'Our Shared Environment' bringing together experts from both Israel and the Palestinian Territories for the first time. Consequently this work led to small collaborative efforts on environmental issues funded by the Canadian organisation, the International Development Research

Centre (IDRC). A further initiative of IPCRI was the Joint Environmental Mediation Service (JEMS) designed to train Israelis and Palestinians in the technique of environmental mediation and thereafter to offer mediation to Israeli and Palestinian stakeholders in conflict over environmental issues. Other environmental organisations that began high profile joint work at this time included BirdLife International.

The changing political climate in the wake of the assassination of Yitzhak Rabin, the election of a right-wing government in Israel and ultimately in the outbreak of the Second Intifada, has threatened and somewhat diminished the enthusiasm for joint initiatives. Whilst some joint organisations and projects fell foul of the changing times, such as PIES which collapsed completely within a year of the Intifada, many joint organisations are weathering the storm albeit in a more low key way, and many of the connections developed in the preceding years have continued. In the current climate, however, it has become much harder to bring together Israelis and Palestinians simply to meet without encountering bureaucratic difficulties.

Indeed, in 2002, another cross-border NGO was founded, the Israeli-Palestinian Scientific Organisation (IPSO) which has also focused on transboundary water issues. In 2006, IPSO participated in a UNESCO project to bring together six Israeli and Palestinian and other experts to establish a framework for joint projects focused on writing a common history for water management in the Middle East.

The major work of cross-border organisations with joint leadership, such as IPCRI and Friends of the Earth Middle East, has been to provide a bridge where relations between official bodies remain unresolved and problematic. As Robin Twite of IPCRI argues, part of the problem between official bodies in Israel and Palestinian Authority is the imbalance of power between decision-makers on both sides.

Whilst the Israeli Water Commission is well funded and resourced, the Palestinian Water Authority has to compete for funding from international donors, and has to deal with the fact that it has limited authority over the West Bank. Thus whilst the Israeli Water Commission may be well meaning in its desire to see the Palestinians receive adequate water of an acceptable quality, its superior situation and negotiating position can lead to it appearing over-confident and patronising. Likewise, recognising their position of weakness, Palestinian officials can appear over critical often repeating demands for the resolution of issues which they are well aware cannot be resolved by the Israeli Water Commissioner, such as the issue of water for the settlements.

Cross-border NGOs can provide a means of communication to enable the two sides to meet on more equitable terms. Further, they can contribute to a resolution of difficulties since they can be more flexible and are not directly involved in the political process.

Friends of the Earth Middle East (FOEME) – Good Water Neighbours Project

One of the cross-border organisations who have continued working throughout the Second Intifada is Friends of the Earth Middle East - the only joint Israeli- Palestinian organisation engaged in work on transboundary issues from a peace-building perspective. The organisation has produced numerous publications on transboundary water issues such as sewage water and the Mountain aquifer. With a focus on problem solving and co-operative solutions, FOEME argue that water issues are an excellent bridge to promote cooperation between neighbouring communities, especially in conflict areas, due to the interdependent nature of water resources.

Initiated in 2001, FOEME's 'Good Water Neighbours' project works with neighbouring communities in Israel, Jordan and the Palestinian Territories. It uses shared water resources as the basis for environmental education, water security and peace-building. The project seeks to encourage dialogue and cooperation between the communities on the different realities of water availability and use in their communities, as well as how shared water resources can be managed sustainably. The project also seeks to directly address water scarcity issues through encouraging saving, reusing and sustainable water practices within each community.

FOEME's work has ranged from developing low-tech water treatment methods and conservation projects at local schools and in public buildings, to summer camps for kids, petitions and designing awareness raising posters. The project has also worked with local mayors and community leaders to build co-operation, as well as lobbying at highest level to the European Parliament and the US House of Representatives. By 2005, the project had established a co-operative work programme between 18 rural communities located on the borders of Israel, Jordan and Palestine.

Beginning shortly after the outbreak of the Second Intifada, this project faced significant challenges: mistakes were made and the project had to be flexible enough to adapt to the constantly changing circumstances. Developing community involvement and trust was a slow process with some participants being intimidated for taking part, and the sense of outrage at the violence perpetrated on both sides of the conflict, a significant barrier. For this reason, the regional co-operation aspect of the project was initially kept at a low profile, with a focus on real investment in physical improvements in the communities, as well as hiring locally respected workers. As trust developed over time, regional meetings became not only possible but ‘desirable’ with the ‘other side’ becoming a point of intrigue rather than a source for suspicion.

A powerful example of how these grassroots connections have developed through the ‘Good Water Neighbours’ project beyond simply the water connection, is the story of the West Bank village of Wadi Fuqin. Here the villagers, with the vocal support of the FOEME and the neighbouring Jewish community of Tsur Hadassah, have taken legal action to prevent the Separation Wall from being built beyond the Green Line which would have affected the recharge area of the streams that flow into the village and cut villagers off from their olive trees. The court did not contest the petition and the wall has subsequently not been built there. These two communities are now developing a joint ‘development plan’ for the area which includes environmental, economic, and social considerations, as well as a sustainable tourism initiative.

Meanwhile, joint initiatives in Emek Hefer and Tulkarem, between the Jordan River Valley mayors, and between Baka al Gharbia and Baka al Sharkia have yielded direct funding for co-operative projects, generating real solutions to ease the water and sewage problems of all residents.

In future years, funding is being made available by USAID and the European Union for more grassroots work based on this model of incorporating peace-building into development and community assistance projects, such as water management. Such funding to develop more projects like these can only be of benefit to the region.

Joint working from an Israeli perspective

With plenty of work to be done to protect water courses and prevent pollution from sources inside Israel and the disappointment of the collapse of the peace process, it is perhaps not surprising that for most Israeli environmental organisations, cross boundary issues are not currently high on the agenda. In some cases this is organisational policy, for example Adam Teva V'Din does not work over the Green Line, although it did take one case against the establishment of a landfill for Israeli waste being established in a settlement on the West Bank.

Notably, few Israeli peace organisations have comprehensively addressed water issues except for humanitarian efforts. For example, several years ago the Givat Haviva Institute part of the Hashomer HaTzair youth movement, provided tankers of water to provide relief for West Bank villages facing drought. Several Israeli human rights organisations do, however, address this issue. B'Tselem and Yesh Din both address the issue of Palestinian access to the shared water sources of the Jordan and the Mountain aquifer from a human rights-based perspective.

In terms of joint research initiatives, the Arava Institute for Environmental Studies, based in the South of Israel, continues to draw students from both Israel and the West Bank and has also carried out joint research on shared water resources, most notably a stream restoration project on the Alexander/ Schem river with students based both in Israel and the West Bank supported by a Middle Eastern Research Council grant from USAID. Another USAID funded project ran from 2001-2004 between Hebron University, the Technion in Israel and the Royal Scientific Society in Jordan to reduce the environmental impact of olive mill wastewater in the region, a major transboundary pollutant.

Since 2007, the Towns Association for Environmental Quality in Sakhnin, Israel, has worked in partnership with the Centre for Environmental Diplomacy in Ramallah to support Palestinian water engineers to establish waste water treatment facilities in their own communities with support from the Adam Institute and the European Union. This work builds on a previous USAID-funded project to promote appropriate technology for wastewater treatment with project partners in Egypt, Israel (Sakhnin) and the Palestinian Territories.

In 2008, Israeli research institute, the Van Leer Institute established a joint Israeli- Palestinian Study Group on Protection of the Environment in co-operation with the Palestinian Peace and Freedom Youth Forum. The aim is to further involve Israeli civil society in transboundary environmental issues, and it brings together students to study environmental issues and dilemmas of common interest including water, solid waste and the ecology of the Dead Sea.

Joint work from a Palestinian perspective

Joint working is also not always relevant in the Palestinian context. Since the two political entities are at such different levels of socioeconomic development and civic education, it is understandable that there is not always 'common ground' between Israeli and Palestinian NGO's. Priorities for one are likely to be discounted or ignored by the other.

Besides, Palestinian organisations take accusations of 'normalisation' seriously - the implication being that by co-operating and working with Israeli organisations they are accepting the status quo of the Israeli Occupation. Further, from a political perspective, it remains a fact that until the Palestinians receive full independence and a resolution over shared water resources with Israel, it will be a challenge for Palestinian organisations to engage in long term planning for water management.

There is also, however, a widespread understanding that in the current context, water access and sanitation are basic humanitarian issues, and that some degree of co-operation with Israel is necessary due to the transboundary nature of the issue. Even Hamas in Gaza have indicated that they are open to discuss water management issues with Israel through a mediator. Therefore some major Palestinian water-focused organisations, such as PHG and ARIJ have worked on joint projects with academic institutions in Israel. Palestinian organisations have also worked together in the context of large regional projects focused on the future of the Jordan River valley such as the German government funded GLOWA project.

Joint initiatives between academic institutions and NGOs as well as cross-border NGOs focused on transboundary environmental issues have clearly been invaluable in keeping discussions open and pushing towards a shared vision, especially at times when the conflict has been most fierce, and official channels have been restricted and unconstructive. It is evident from the experience of the last 15 years, however, that such projects are vulnerable to the rapidly changing political situation which sets the tone for how open and straight-forward or how complicated such co-operation can be.

The role of Palestinian and Israeli civil society in future peace agreements

NGOs working on transboundary water issues with many years of experience of joint working often have a far better grasp of the issues and the need for long term equitable solutions than the officials designated to make decisions, who are mostly driven by short and expedient political thinking. This presents a challenge for NGO's attempting to become involved in the formal political process. Where they can most influence the agenda is through solid research and innovative thinking.

Examples of innovative thinking abound such as the call by Friends of the Earth Middle East for the Dead Sea to be declared a UNESCO World Heritage site or for the foundation of a joint Israeli-Palestinian Water Committee to represent major stakeholders and function as an advisory board for both the Israeli Water Commission and the Palestinian Water Authority.

A further example is the water annex of the Geneva Accords: an attempt by civil society to draft a peace agreement acceptable to both Israelis and Palestinians in order to influence in peace process. However, this project has also highlighted several key points of disagreement both between participants and between a short and long term vision. Drafted by water experts, David Brooks and Julie Trottier, the water annex has not yet been agreed on by other participants in the process: with the Israelis wanting minimal co-operation with a focus on hydrology, and the Palestinians wanting hard numbers of how many MCM of water they would receive in an agreement. The draft annex itself is much more holistic, highlighting 'water for people' followed by 'water for nature' and only then 'water for agriculture'. Neither Israeli nor Palestinian negotiators can agree, however, to prioritising 'water for nature' about ‘water for agriculture’ instead prioritising economic needs above the needs of the environment and the vital eco-system services it provides.

There is a general agreement amongst Palestinian NGOs that the Oslo Agreement did not result in a just outcome on water issues. For this reason, water organisations have lobbied hard to be included in any new peace negotiations towards a final status agreement where water must be a component. In 2007, the Palestinian Steering and Monitoring Committee who lead negotiations with Israel invited civil society, including NGOs, research organisations and business organisations with an interest water issues to be involved in discussions on the final status negotiations. Meanwhile during the good years of the Oslo process, Friends of the Earth Middle East was informally invited as an observer to Joint Environment Committee meetings and asked to contribute ideas. In 2003, the Water Commission also became more open for dialogue on transboundary issues. Whilst Friends of the Earth Middle East has always pushed the government to move forward on the peace process and prepared documents with creative ideas on how to resolve transboundary environmental issues, other Israeli organisations have shown less interest in being formally involved in the process.

A final way in which civil society can influence the peace process is through encouraging international involvement. This could include international mediation by a neutral third party – an idea suggested independently by both the World Water Council and Green Cross International. This could be invaluable if both sides were willing to accept that left to themselves, they may have difficulty in reaching a mutually acceptable agreement.

Conclusion

In the light of population growth, existing water stress and climate change, it would not be unreasonable to propose that without co-operation on water management between Israel and the Palestinians (and their neighbours) both sides face an uncertain future. Co-operating to improve water infrastructure, to share technologies for desalination and recycling effluent, to promote an ethic of water conservation and preserving water resources, and resolution over disputed transboundary water sources offer some hope of a sustainable future for the peoples living in the region and the environment.

Civil society organisations, especially cross-border organisations, offer a way to move beyond the political crisis, to address water issues without the heavy political baggage that surrounds the Israeli-Palestinian conflict. Civil society organisations can also offer innovative ways beyond the impasse, including engaging international civil society. Practical contributions by civil society organisations towards resolving the conflict include generating shared research, as well as offering practical support through technology transfer and capacity building.

On a grassroots level, connections between neighbouring communities forged by groups such as Friends of the Earth Middle East are invaluable in terms of raising awareness of the environmental justice issues. Perhaps the most important role of civil society towards resolving the transboundary water issues is, therefore, the personal connections and trust forged both in communities, as well as by environmentalists and scientists who have worked together on common concerns over the years. Such work has led to shared understandings and assumptions about these issues and provided a forum for ongoing discussion, despite the changing political situation.

Areas of shared interest

- Avoiding damage to shared water sources (both streams and groundwater) through both sewage treatment and preventing over-pumping. Both Israeli and Palestinian NGOs are focused on preventing pollution. For Palestinians, this issue is framed in terms of creating the relevant infrastructure to avoid contamination, and for Israel this issue is framed in terms about protecting the environment and preserving open air spaces.

- Forums for Co-operation – Some Israeli and Palestinian NGOs recognise the value of building long term and personal connections and creating "water and environment community" of experts, academics and officials, members of which work together based on shared assumptions in spite of the political situation.

- Greater voice in the peace process – This is an area of shared interest for both Palestinian NGO's keen to avoid another situation like the Oslo Agreement, for joint Israeli and Palestinian organisations, as well as for Israeli NGO's focused on environmental justice and human rights issues.

Areas of disagreement

- Due to the drastically different socio-economic situations in Israel and the Palestinian Territories, NGOs from each respective political entity often have different priorities.
- Most Israeli environmental NGOs are not interested in addressing Palestinian water issues, apart from where they impinge on Israel. Most Palestinian environmental NGOs have no choice but to deal with transboundary water issues.
- Palestinian environmental NGOs are keen to influence the peace process based on a desire to achieve an equitable and reasonable agreement over transboundary water issues. In Israel, only human rights organisations are interested in influencing the peace process, as well as cross-border NGOs.

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14. The Role of Third Parties in Conflict Resolution

In order for the Palestinian state to develop and maintain its water resources sustainably, for the foreseeable future, foreign assistance will play a critical role. Retired diplomat Robin Twite has been involved as a mediating force in the field for over fifteen years and is widely accepted as an objective authority by both Israelis and Palestinians. This chapter offers his insights about how the international community can play an effective role in expediting programs and projects that will contribute to resolution of water conflict in the area.

The Role of Third Parties in Helping to Resolve the Conflicts Over Water Issues In Israel and Palestine

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It is by now almost axiomatic that third parties have a key role to play in resolving the conflict between Israelis and Palestinians. Since 1948 the two peoples have struggled to resolve their differences but with little success. Again and again outright conflict has been succeeded by an uneasy truce but there has been no real resolution of the issues of concern to both parties. Unhappily this still remains true. Over the whole of the period since the establishment of the State of Israel third parties, individual states and international organizations, have attempted to intervene constructively but with only limited success. NGOs and academic institutions in the region can, in some sense, be classed as "third parties" since they have strive to play a constructive role in allieviating the conflict and have made use of international funding. Their efforts have also had marginal impact.

It is the purpose of this chapter to look at the role of third parties in relation to disputes of water resources between Israelis and Palestinians since 1994. Water is in short supply in both Israel and Palestine and it is inevitable that there will be disputes as to how it can best be managed. These have been exacerbated by the fact that since 1967 Israel has been largely able to control the way in which water is distributed in the region.

Over the years since 1948 there have been two principal ways in which the international community has sought to resolve conflict over water. The first has been the active intervention at the international level in water disputes and the second, particularly in evidence since the early nineteen nineties, the provision of aid to assist in the development of water resources and their effective management.

International Initiatives

Among the international level significant interventions which have had an impact on the situation regarding water since the establishment of the State of Israel have included the negotiations surrounding the Johnson Plan in the 1950s put forward by the US President's special envoy, after whom the initiative was ultimately named. In retrospect, this was considered to be successful, even though the plan was never formally accepted by all parties. The framework it created had a definite impact on the way water issues were handled in the Jordan basin from the late fifties onwards. It was this type of initiative which representatives of the international community had in mind when they included water issues in the Oslo accords in 1993/4.

The Oslo Accords were the most important contribution to resolving issues related to water which the international community has made in recent years. Their most significant features were the clear recognition of Palestinian water rights, agreements on water pumping by Palestinians from the mountain aquifer and provision for the setting up of the Joint Water Committee on which senior officials and experts from both sides sit and discuss water issues. Also of use, particularly during the 1990s, was the work of the Multi-lateral Committee on water resources, established as part of the effort to resolve the conflict between Israel and Palestine immediately after the Madrid Conference in 1993. This working group (like the other five multi-lateral negotiating committees on other key issues including the environment) was intended as a forum in which Israelis and Palestinians could meet with representatives of countries interested in assisting the development of the region and in peace so that they could together work out agreed policies. In practice they achieved much less than had been hoped for(see below).

The Provision of Aid to the Water Sector

These efforts to provide a framework for mitigating, and hopefully in the long term resolving, the conflict over water in the region, were supplemented shortly after the establishment of the Palestinian Authority, when the international community, backed by individual foundations and NGOs, undertook a major effort to assist in the development of water resources in the Palestinian Authority areas.

This effort was designed both to improve the quality of life of the people of the region by providing additional water resources and, in the long term to promote understanding and a peaceful resolution of conflicts over water. The aid programs which resulted were almost all designed to assist the Palestinian Authority directly. As Israel's economy was successful and its GNP relatively high, the great majority of countries and international organizations declined to provide aid funding for projects which were, even in part, within its borders. However, in addition to funds for the Palestinians, some limted funding was made available to universities and institutions of higher education for projects which enabled Israelis and Palestinians to work together on research related to water issues within a scientific and academic context, as well as to NGOs which promoted mutual understanding and compromise over water and environmental concerns.

It is the main focus of this chapter to look at what the international communities' well meant efforts achieved when seeking to resolve conflicts in the water sector, in particular what degree of success resulted from providing aid to the sector over the fifteen years since 1994. This will mean making a brief assessment of these efforts, and in particular looking at what factors have limited their impact. The chapter also will suggest what can be done to help the international community make a more effective contribution, using aid as its instrument, to the development of the water sector in the future.

What Motivates Third Party Intervention?

It may be worthwhile at this point to look at the factors which govern the attitudes of third parties in long running conflicts such as that between the Israelis and Palestinians. Motivations for involvement in conflicts which have deep roots are always mixed. It is possible to distinguish here between three types of aid providers - individual states providing bilateral assistance, international organizations distributing funds on behalf of the international community and private foundations.

Where individual states are concerned economic self interest undoubtedly plays a part; aid programs almost always have a recognizable economic dimension. International assistance has often been given with all manner of conditions which meant that the recipient has had no choice but to use the donor's equipment and hire its experts.

Where the Israeli/Palestinian dispute over water is concerned such economic motivation has not been paramount. It is true that individual bilateral donors have used consultancy companies based their home countries and that in some cases pumps and other equipment have been provided by the donors using their own countries' resources, thus providing work for the firms producing them But these considerations have not been central. The region is small and the economic benefits to be derived from aid to the environment and water sector are not economically significant. .

The wish to play a part on the world stage, which is also an aspect of national self interest, undoubtedly influences some players. When the Multinational Committees on water resources and the environment were established in 1994 as mentioned above, their efficacy at first was diminished by the fact that a number of states signed up as partners in the various committee though they had little experience in the region and lacked the resources to be of real assistance. They wanted to be part of the program and to be seen to be active. While it might seem reasonable to involve as many potential partners as possible in the aid process, in the event the participation of countries with nothing to contribute slowed up the process.

While economic considerations and a desire to play an international role evidently provide some part of the motivation for aid programs in the region, there are others. Some part of the motivation of donors lies in fear. A dispute such as that in Israel and Palestine threatens the peace of the Middle East and can, like a small fire, spread uncontrollably. Enlightened self interest is undoubtedly a factor.

Also important in some cases is the influence of particular national groups within the donor states own society (notable instances of this being the influence of the Jewish community or of the Christian right in the USA), and a wish on the part of individual statesmen and administrations to be seen to help resolve conflict so as to gain political credit at home.

However altruism and idealism also have a role. These considerations influence particularly NGOs but they also motivate many staff members working in air programs who become genuinely concerned at the impact of their programs..

So far as international bodies (such as the various UN agencies or the World Bank) are concerned, more idealistic motivations are at work(though it would be a mistake to regard such agencies as removed from the influence of member states upon their policies). The same is true of major private foundations working in the region where a wish to at the same time improve the quality of life of the people and to promote peace combine to motivate their efforts.

Limitations on Progress After Oslo

In 1994 when the Oslo Agreements were signed and recognized as the template which could provide a basis for long term settlement, it was clear that funding would be available for substantial projects in the water sector. All parties shared a perception that they were entering a new era in which cooperation was recognized as important and resources existed to support positive development.

Today, thirteen years later, things look less promising than had been anticipated. In this respect activities related to water are not different from others. The outbreak of the second intifada in 2000 and political developments in the region since then have had an adverse effect on relations between Israelis and Palestinians at all levels.

The Joint Water Committee still meets but the Multilateral Committee on Water Resources, like the parallel committees, has not met for some years. (Certain initiatives which were undertaken under its auspices still survive – among them EXACT, a data base on Middle Eastern water resources and Middle Eastern center for work on desalination in Oman – these, though useful in themselves, are not of major siginificance). Both Israelis and Palestinians were discouraged by the limited results of the Committee and it appears to have died simply through inanition..

So far as aid is concerned in the last fifteen years large sums have been provided, major works undertaken, a variety of research studies completed, but many important projects though planned have never been realized. As a result, a sense of deprivation persists among Palestinians who return again and again to the question of "water rights" while for their part Israeli officials and experts view what is happening in Palestine with a mixture of irritation and condescension. They are particularly critical of the failure of the Palestinians to deal with the treatment of waste water which they ascribe to Palestinian incompetence.

Professor Marwan Haddad, for over a decade a prominent exponent of cooperation between Israelis and Palestinians in the field of water, expressed the Palestinian sense of frustration in a recent article where he stated that discussing with Israelis only water needs and quantities separately from water rights will end by making the Palestinians having no control over their water supply or quality. He goes on to say that . . . .Palestinians fear that accepting such an approach will end in separating them from their land and their resources.

For their part Israeli officials are never tired of pointing to the fact that while the international community has been willing and able to pay for the construction of waste water treatment plants in the West Bank and Gaza only about five per cent of Palestinian waste water is being treated and the flow of untreated sewage in the ground threatens the integrity of the mountain aquifer which is a key resource for both Israelis and Palestinians.

How is it that in spite of the reasonable sense of optimism that both parties felt in 1994 and the genuine wish of the international community to assist them reach a long term settlement of outstanding issues over water, genuine agreement has proved so far unattainable? The disappointment was apparent even before the outbreak of violence in 2000 did such damage to Israeli/Palestinian relations.

The question is especially salient because there were successes. For example, deep and important new wells were dug in the West Bank using American and other aid funds. These substantially increased the amount of fresh water available in Hebron and elsewhere. It is also evident that distribution systems in the West Bank were extended and more communities received piped water while the monitoring of existing resources, improved. At a different level, a number of significant research projects involving Israeli and Palestinian scientists and academics took place and the efforts of NGOs such as Friends of the Earth and the Israel Palestine Center for Research and Information (IPCRI) were instrumental in bringing together officials, academics and professionals in a variety of contexts, including seminars, conferences and on the ground projects. The cumulative effect was the formation of a community of individuals involved professionally in the water field whose desire to cooperate is evident.

But in spite of these positive features, the general picture is somewhat gloomy. A great part of the responsibility for the failure to resolve conflict over water must, of course, be attributed to the political situation. It was not to be expected that water issues could be separated from other controversies and that peace would prevail over the division of water resources when violence and mutual suspicion dominated elsewhere. At the same time, there is still room for considering what has diminished the ability of the international community to help resolve the water issue.

Why was progress towards a solution so limited?

Looking at the over-all situation, it is possible to discern certain factors which would have made effective resolution of the problem difficult even had a better atmosphere prevailed. Among them is the fact that Israel had the controlling interest from the outset. It is difficult to achieve parity when one party in a conflict is so evidently weaker. Israel negotiated from a position of strength, Palestinians from one of weakness. This simple and inescapable fact had adverse effects. For example it damaged the effectiveness of the Joint Water Committee. From verbal accounts of what happened at the many meetings of the Committee (the minutes are not in the public domain) it is evident that while most members of the Committee worked well together at a personal level, the Palestinian representatives felt themselves to be in the position of junior partners. Palestinians had to ask permission of the Israeli authorities for relatively minor matters and were in no position to challenge Israeli decisions about the use of water within Israel proper, even though it might impinge on the water situation in the West Bank and Gaza. So difficult did meetings become that a prominent official in USAID said, off the record, in an interview in 1999 that without active pressure from his government, the Joint Water Committee might well have ceased to function.

At a different level the fact that the Palestinian administration generally was not always effective clearly impeded successful implementation of projects.. Water management was no different in this respect than other areas of concern. Nor was this a surprise. The civil administration the Israelis created in the West Bank and Gaza worked well with Palestinian local authorities and other professionals until about 1977. From that point on, relations deteriorated and Israel dominated all important decisions about water management, much as it controlled most other aspects of life of the Palestinians until the signing of the Madrid agreements.

In the twenty years subsequent to the Six Day War in 1967. Palestinian administrators and staff had limited responsibilities and worked mainly on local issues in their town or rural area. In 1994 Palestine was a state in the making and the norms of the civil service and the many agencies working in the area had to be established. Moreover the human resources available to the Palestinian Authority were not comparable with those available to Israel. There were within the Palestinian Water Authority, in local government and in academic institutions men and women with excellent qualifications but they were relatively few. The Israeli Water Commission could draw on the expertise and knowledge of thousands of experts in its own ranks, in other professional organizations such as Mekorot, in universities, and in research institutes; its opposite number in Palestine on hundreds.

In retrospect it seems clear that aid agencies, anxious to show results, did not make sufficient allowance for the inadequacies in the human capacity among the recipients of aid. Training programs for staff in the water sector were undertaken by donors but they were not coordinated and those trained were not always able to use their new found skills in the existing bureaucratic structures. As late as 2004 USAID was proposing to spend twenty million dollars over five years on training technical staff for the water sector. This constituted a sign that it recognized the need to strengthen the capabilities of the Palestinians involved. (This program was ultimately cancelled after Hamas took control of the Palestinian Authority in 2006).

On the whole it can be said that aid agencies in their water programs took too little cognizance of the weakness of the Palestinian state. Though they provided expert advisors some of whom wrote excellent reports, the existence of these individuals had a limited impact. Most worked for a relatively short period (between two and four years) and were replaced by others who had to learn the local situation afresh. This is, of course, a usual hazard of aid work, but in the case of Palestine it had a particularly negative effect because of the relative inefficiency of the Palestinian ministries and agencies. More direct involvement was perhaps necessary on the lines of the arrangements made in Amman where the office of GTZ, a German aid agency which has given much help to Jordan in developing its water resources, is housed in the same building as the relevant Ministry and firmly implanted there.

A particularly striking and instructive case relates to the World Bank's efforts to improve solid waste disposal by building sanitary landfill sites in the West Bank . This involves the water sector indirectly, since solid waste disposal's effects the water quality of the adjacent aquifers are well known. In this case, plans were made in the late nineties for the establishment of two state-of-the-art disposal sites: one in Jenin in the north of the West Bank and one in the south in the Hebron area. The plan for Jenin was in fact implemented, though it is not yet fully operational for logistic reasons. The selection of a site for the Hebron region was stymied by the attitude of the Hebron local authority which refused to cooperate unless the site it preferred was selected. This site was within the municipal borders of Hebron. Other potential users of the site such as the town of Bethlehem objected and no decision was taken on the selection of a site. No effective mechanism existed for over-riding these obstructive positions. Only recently has work begun again to resolve this problem.

While cases such as this reflect directly on the ability of the Palestinian Authority to respond adequately to donor initiatives which it had initiated itself, other
efforts to assist were frustrated by wider political considerations. Most notable in the water field was perhaps was the fact that while donor funding existed for the construction of a waste water treatment plant in East Jerusalem, such a plant was never built. The difficulty, which has yet to be resolved, lay in the reluctance of the Palestinian Authorities to agree that waste water from Jewish settlements should be treated at the plant as well as that from East Jerusalem and Bethlehem. In the view of the Authority this constituted de facto recognition of the settlements' legitimacy and was a step on the way to normalization of their existence. Partly as a result of considertions of this type, over a decade after the Oslo agreements less than ten percent of waste water in Palestine undergoes any kind of treatment.

In yet another case when good intentions fell victim to the impact of violence: a desalination plant in Gaza (for which USAID was providing funds and development of which was well advanced and included a distribution system) was halted in 2003 when three US government employees were murdered and their murderers were not brought to justice. It has never been resumed.

The work of international agencies has also been impeded by reluctance to acknowledge the validity of criticism. A striking example of the latter was provided by the fate of a desk study on "the Environment in the Occupied Territories" which UNEP undertook in 2004 and which contained a large number of recommendations as to how the situation could be improved. Many of the concrete suggestions related to water management. The desk study was widely circulated but its recommendations had little impact. Both the Isrsaeli Ministry of the Environment and the Palestinian Environmental Quality Agency appeared to feel that they were the target of criticism and were unwilling to respond effectively.

Factors such as these outlined above weakened the impact of the efforts of the international community to assist the Palestinian Authority to make better use of the water it has and so contribute to a climate in which both Israelis and Palestinians could look at water issues in a more relaxed and hopeful atmosphere.

Non-Governmental Initiatives

For many years – from 1967 to the early nineties - assistance from international agencies, overseas governments and private foundations, reached Palestinian society through institutions of higher education and NGOs where practical and research work on water issues was being undertaken. NGOs such as the Palestinian Hydrology Group based in Ramallah, Anera, and the Applied Research Institute based in Bethlehem were particularly successful in attracting funding from the Arab world and international donors for work on water issues. Their work, particularly in rural areas, and in the preparation of reports on the situation, has had a positive impact. But their reach was limited and they did not enjoy the authority of power. With the creation of the Palestinian Authority their role somewhat diminished but they are still important players within the West Bank itself and attract some international funding..

It is not easy to assess the impact of non-governmental initiatives in a cross border context. . Recently IPCRI made an effort to draw together information about joint projects relating to water undertaken by Israel and Palestinian institutions of higher education and by NGOs seeking to promote Israeli and Palestinian cooperation, since 1994.. Information was collected about over fifty such projects. Some addressed problems such as the management of the mountain aquifer which lies under Israel and Palestine or the future of the Dead Sea; others explored questions relating to water quality, while yet others aimed to provide a framework within which Israelis, Palestinians and international experts could share their knowledge. The aggregate total amount of funding directed by donors these initiatives were tiny compared with the amounts given by official aid agencies to the Palestinian Authority. Some projects resulted in valuable, reports, program evaluations and publications, but it was hard to find any concrete information about many others as to what was achieved. In general evaluation of such projects left much to be desired though some left important publications as their legacy. There is, however, a consensus among those who participated in the survey that the work done had contributed to the creation of a "water community" of experts from Israel and Palestine who were personally acquainted, who understood one another's concerns, and who could work together when required.

Conclusions – the Way Forward

It appears that in spite of the genuine wish of donors to help mediate the conflict over water and improve the management of water resources in the region, social and political factors have in no small measure frustrated their efforts. Much effort has gone into projects, preparing reports and debating the water problems of the region. But the issues are far from resolved.

The question then arises "what can be done to improve matters in the event that the general political situation improves?" Assuming there is a genuine wish on the part of third parties to assist, how should they proceeded once the current impasse is resolved and a degree of normalcy return to the region. When negotiations over water are resumed it seems that the international community will need to take a lead role as it has tried to do earlier. Large sums are needed to fully exploit the water resources available to Palestinians and add to the total amount of water available through desalination and the treatment of waste water. Neither the Israeli authorities nor the Palestinian are likely to change their basic attitudes in the near future and the work of third parties has to be directed to creating efficient mechanisms for cooperation, the distribution of aid, and the implementation of projects. This is especially true, because so many of the solutions to the conflict involve investment in infrastructure, something that the funding associated with a final agreement should be able to provide.

The work the Joint Water Committee, valuable as it is, needs to be made more transparent and allow for more involvement of major donors in its work. USAID is already closely linked to the Committee, other aid agencies should be also.

It would also be valuable to provide a way in which a mechanism could be established for resolving individual and local disputes over water using techniques for environmental dispute resolution developed over the last two decades in North America and Europe. Thanks to the work of NGOs, notably IPCRI, there is already some familiarity with these techniques in the region and .a new initiative designed to create such a body might bring positive results

It might also be worth considering the establishment of a “Water Council” containing Israeli and Palestinian experts which could act as a semi-official forum for the airing of concerns. This could be managed by an appropriate international agency or an NGO. Such ideas have already been floated in a variety of forums but lack of political will prevented their implementation.

In an effort to create a better atmosphere, the international agencies and national donors would be well advised to make more of an effort to involve the Israeli Ministries and the Water Authority in their work. Many donors have their offices in the West Bank(a notable exception is USAID which hs its offices in Tel Aviv) and little or no contact with the Israeli authorities. This is a pity since ideally their work should benefit both parties. If it is possible to permit aid to go to Israel in specific cases where the water problem is cross-border this would be a great advantage for all concerned.

As far as work on the ground goes, donors should keep professional staff at their local posts for as long as possible, certainly not less than four years, to ensure continuity in their work. The need for cooperation among donors is self evident and efforts have been made to secure more effective sharing of plans and information. A committee of representatives of donors to the Authority exists and should continue to meet. Donors tend to be competitive, with some proposed projects simply more attractive than others. It is up to the recipients of aid to discern where there is overlap and inform potential donors so that resource utilization can be maximized and the consequences of "competition" are not serious. This is particularly true in the realm of procurement, where incompatible hardware or other equipment presented by different donors can cause serious problems.

Donors should also consider extending more funding to the academic institutions and NGOs which are working to bridge the gap between the two sides. Such funding should also provide adequately for the overheads of the recipient organizations, many of which have little by way of endowment funds to cover their basic expenses. Funding for such NGO activities can benefit all parties. NGOs by their nature are able to promote community involvement(as Friends of the Earth has done, provide training for professionals from both communities(as the Arava Institute has done) and help to establish a professional community(as IPCRI has done)   Univerisities and research institutes can establish long-term cooperative research programs, the results of which can benefit all parties.

But if more funds are provided for NGOs and academic institutions, the international donors should also monitor more closely the results of such efforts. More effective monitoring, including specification of clearer performance indicators and timetables should be a integral part of the whole process. A mechanism is need to coordinate the efforts of NGOs and academic institutions – perhaps the provision of a special fund to which a number of key donors contribute.

All this will only be possible if there is an adequate degree of flexibility on the part of those involved. The structures of decision making within Israel and in the Palestinian Authority areas are not always such to promote cooperation. Besides the actual water authorities on both sides many other government ministries, from defense to health, feel they need to participate in decision making about water. Only direction at a high level, from senior members of the governments of both sides, can change such negative dynamics.

The representatives of the donor community working through national governments and international agencies will need to influence senior political decision makers and convince them through persuasion and with funding, that cooperation pays. To do this effectively individual officials they will need to have a keen and personal interest in the work they are doing and its results. They will not be able to sit in their offices and "administer" but will have to go out and familiarize themselves with people they are working with and their daily considerations. They will have to care for the welfare of the communities in which they work at both an official level and more personally. Such effort to humanize aid will pay dividends in the long run.

Cooperation pays and third parties can help to promote it. They need to be vigorously involved both at a policy level and through the distribution of aid and the promotion of joint projects. Without such efforts the water problems in the region can never be dealt with effectively.

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15. **Cooperative Water Management Strategies**

Ultimately, innovative institutional frameworks will need to be created for "joint" Palestinian/Israeli management of water resources to be effective. Eran Feitelson and Marwan Hadad have collaborated in numerous publications on this subject, providing numerous ideas for possible models. This chapter offers their latest thinking on the subject.

Joint Aquifer Management – Institutional Option

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The Mountain aquifer, composed of three sub-basins, supplies approximately a third of the Israeli water consumption, and is the source of almost all the water supplied to the Palestinians in the West Bank. Due to the properties of this aquifer, it has long been suggested that it should be managed jointly. If the two parties do indeed intend to manage this shared resource judiciously, it is likely they will need to come up with innovative management structures. A series of such options have been proposed in the past for such an option. In practice a coordinated management structure was established in the interim agreements (Oslo B) signed in September 1995. This structure is composed of a joint water committee (JWC) and joints supervision and enforcement teams (JSETs). Early experience with this structure led to arguments that it is insufficient, and that there exists a need to move to more sophisticated structures. Practical steps to this end were also proposed in lieu of the permanent status negotiations that were expected at the time.

This chapter considers possible frameworks for joint management structures between the two parties. It begins by briefly reviewing the set of options identified in prior work. Then, the implications of a complete breakdown in relations, resulting in separate management, are reviewed. A discussion of these implications shows that there are still options that may be worthwhile pursuing. Some steps for advancing such options are raised in the conclusion.

The Options: A Brief Review

There are four basic options for managing a shared aquifer:

- separately,
- in a coordinated manner,
- jointly, or
- by delegating responsibility to an outside body.

Under *separate management* each party sets its own policies, drills its own wells, determines its own extraction rates, and sets its own standards. *Coordinated management* implies that each party manages the aquifer within its own territory but coordinates its actions with the other party. This is in essence the type of structure established under the Oslo B agreement. *Joint management* is the situation whereby a single institutional structure is established to carry out certain tasks viewed by the parties as the most crucial for adequate management of the aquifer. *Delegated responsibility* involves assigning responsibility for the aquifer, or for some management tasks, to an external body. This could be a regional or international body, or a privately-owned corporation.

In practice, the sustainable management of any aquifer requires that many actions be undertaken.[vii] These include determination of pumpage regimes and rates, drought policies, protection measures, monitoring, enforcement of restrictions on pumpage and land use, recharge enhancement projects, wastewater treatment standards and reuse policies, and crisis management measures. In addition, coordination of research as well as monitoring and sharing of data, models, and expertise facilitate a more effective management regime. Thus, any structure for managing a shared aquifer can potentially address multiple issues. The extent to which it does so is a function of the terms of reference set for the structure. Therefore, there are many options for transboundary bodies, ranging from bodies that coordinate a single activity to bodies that manage the aquifer comprehensively.

In previous work, a flexible-sequential framework for the management of shared aquifers was proposed. It suggests that initially a limited number of activities be undertaken jointly. These could serve as the basis for cooperative management structures. Additional activities would then be added to the purview of the structures over time. The added activities could lead to one of five basic orientations, according to the rationale chosen. Alternatively, from the second stage onward, activities could be added so as to expand the scope of the structure to include additional orientations. The five possible orientations identified were:

1. resource protection, whereby the activities are geared toward the protection of the aquifer;
2. crisis management, whereby the focus is on managing crisis situations, as in such situations the most contentious circumstances arise;
3. efficient water use, whereby the focus of the structure is assuring the efficient use of water, most commonly through a trading system;
4. effective water supply, where the management of the extraction of the water and its distribution to consumers, and perhaps also the collection and treatment of sewage, are entrusted to a third, private, company;
5. comprehensive-integrative management, whereby an attempt is made from the outset to manage all aspects of the aquifer. This is the direction suggested in the Bellagio draft treaty (Hayton & Utton, 1989).

We suggest that as resource protection and crisis management constitute the most imminent concerns, it might be most appropriate to focus on them during the early stages of implementation. Establishing transboundary markets or franchises were seen as more problematic, given the complete inexperience locally with such structures. A comprehensive-integrative approach is also seen as an unlikely early structure, given the inherent complexity and lack of confidence between the governments

Issues Raised by Separate Management

As the transaction costs associated with establishing cooperative management regimes escalate, the likelihood that the aquifers will ultimately be managed separately increases. If a separation regime can endure, it is indeed unlikely in the foreseeable future that a cooperative structure will replace it, given the loss of confidence between the parties since September 2000. To assess whether there is a chance that a separate management regime will endure, it is necessary to identify and assess the issues such a regime raises. These are outlined in Figure 2.

Under separate management each side will determine its own pumpage regime. The Palestinians are likely in this case to increase their extractions, given the current shortages and their desire to reduce their dependence on Israel. Israel can respond to this likely development in one of two ways. It can reduce its pumpage so as to assure a sustainable yield, or continue to extract all it extracts currently. While the first option may lead to confidence building and thus possibly to better results in the long-term, it is counter-intuitive and contradicts much of the current Israeli thinking. Hence, it is more likely that the result will be a race to the bottom, as the aquifer will increasingly be over-pumped. The full implications of such massive over-pumping are not fully known, due to the uncertainty regarding underground saline water bodies. Still, it is clear that the threat of salination of the aquifer will rise and that water levels will drop, consequently raising extraction costs.

A second issue that is likely to arise is that of pollution. This includes both pollution from landfills and other point sources, and wastewater collection, treatment and reuse. As most of the recharge zones are in the West Bank (see Figure 1), it is likely that the Palestinians will have a disproportionate effect on this issue. The degree to which there will be point source pollution will be a function of solid and hazardous waste handling in the Palestinian entity and of land use regulations therein. Given the multiple challenges that will face a new Palestinian entity, regardless of its exact boundaries, it is unlikely these issues will receive much attention, at least during the initial years. Thus, we can expect both point and nonpoint pollution to worsen as a function of population growth, economic growth, and changes in economic activities.

Currently, most of the wastewater generated in the West Bank flows untreated over the aquifer recharge areas. Some initial steps have been undertaken to build new wastewater collection and treatment plants on the West Bank with external funding. However, much of the West Bank is not yet sewered, and almost none of the wastewater is treated to a secondary level. Even with external funding it is likely that it will take considerable time before these problems are addressed. Moreover, the success of wastewater treatment is a function of the level of maintenance. Therefore, the mere construction of treatment plants does not assure that the wastewater will indeed be treated properly.

The wastewater treatment and reuse problem becomes even more difficult when the wastewater crosses boundaries. This issue has been tested in the Tulkarem region. In the Zomar/Alexander watershed, a local level agreement between the municipality and the bordering Israeli regional council was reached. Due to intervention and funding from the German government, primary treatment was established in Tul Karem and effluent levels were upgraded when the discharges reached the Yad Hana plant inside Israel. AS a result, the Alexander river conditions have also improved. In a study of the options for managing the sewage of the Jerusalem region Feitelson and Abdul-Jaber show that separate management is the most costly, and least effective option, and suggest that third party involvement by privatization should be explored. If the levels of distrust preclude any cooperation it is quite obvious therefore that pollution from raw sewage is likely to remain an unresolved problem.

Water supply to the Palestinians in the West Bank will continue to be a problematic issue if the systems are totally separated, especially in drought situations. Given the lack of storage capacity in the Palestinian territories, and the absence of conveyance systems in a north-south direction, except for the Israeli national water carrier, the Palestinians will find it difficult to balance the temporal and spatial variations in supply and demand. Hence, the Palestinians will face significant difficulties in assuring reliable water supply without Israeli assistance in conveyance and augmentation. Thus, even if Palestinians increase their extractions from the aquifers, the population, especially in the cities along the national water divide, may still suffer supply problems, especially in summer and drought years.

Discussion

If indeed the Mountain Aquifer is to be managed separately, none of the issues noted in the previous section will likely be addressed, especially if any attempt to address them will be perceived as providing the other side with a free rider option. Moreover, even if attempts are made to address some of these issues by one of the parties, the costs associated with such solutions will be considerably higher than in any cooperative mode.

Cooperation between the two parties has two potential benefits. First, any cooperative agreement will impose external obligations on the two parties that may induce them to undertake actions that they may not do otherwise. For example, if the water for wastewater exchange idea[xvii] is adopted, Israel will be required to augment Palestinian supplies, particularly in drought situations.[xviii] At the same time Palestinians will be obliged to treat their wastewater to a pre-specified level (probably secondary). None of this would occur in the absence of cooperation. Secondly, cooperation will facilitate greater cost-effectiveness. It will allow for exploitation of economies of scale, better use of resources, and more effective data generation and use.

From a long-term perspective it is obvious that separation is an inferior option. This is particularly, subsequent to the introduction of large-scale desalination in Israel, and will continue to be so – for as long as desalination will remain more costly that pumpage from the aquifer. As long as this condition holds true the deterioration of the aquifer, and the subsequent rise in the cost of supplying clean potable water from it will continue to imply an increase in the overall cost of water supply. Substituting groundwater with desalinated water will result in considerably higher costs.

Over time the deleterious effects of separation are likely to become increasingly apparent. However, groundwater issues are generally less perceptible than other issues (including surface water issues), and the ability to rectify the damage to groundwater is limited and costly.[xx] Thus, it is likely that by the time the damage is apparent enough to trigger action, it may be very late and much of the damage could be irreparable.

All of the adverse results of separation are well known to both parties, or at least to the experts on both sides. The problem with the establishment of cooperative regimes is largely an outcome of what Miriam Lowi termed 'upper politics'. As she correctly pointed out, no agreement on water is likely unless it conforms to the outlines of interests framed by the upper politics. At the same time, all international negotiations are constrained by domestic politics, as all such agreements have to be ratified domestically.

In the context of "upper politics" it is important to note that eight years after the breakdown peace process of the 1990s, neither parties advocates a return to the pre-Oslo "no recognition" stance. Rather, both publicly sides state that eventually they would like to reach an agreement. Despite the violence, there are ongoing discussions between the parties on various issues. The relative invisibility of water, and particularly groundwater, combined with the anticipated tangible benefits, especially better and more reliable supply to the Palestinians, and less pollution to the coastal streams in Israel,[xxiii] mean that specific proposals for joint management of aquifers should reemerge. Moreover, if the confidence building measures within the water field, advanced by Haddad et al. prior to the breakdown in negotiations, are implemented, the transaction costs of cooperation may be somewhat reduced again.

A final status agreement that goes beyond separate management approaches will have to address several thorny questions. For instance, it must resolve how differences will be adjudicated in a transboundary context, and what will happen when certain customers default. Moreover, what will be the legal basis for such structures in transboundary situations, how aere capital costs to be recovered, and how is the oversight of the franchisee to be structured? Moreover, it is necessary to understand what is likely to happen when a two-party situation turns into a three party situation, as will happen when an international firm assumes responsibility for any part of the shared water system. That is, the likelihood that Israelis and Palestinians will cooperate vis-à-vis the international firm (so as to get the best deal and level of services) has to be compared to the likelihood that the international firm will play the two sides against each other thereby worsening the distrust among them.

Conclusions

The current trend in the management of the shared Israeli – Palestinian aquifers is toward separation. However, due to the close inter-relationship between the water sectors of the two parties, and the attributes of the aquifers, this option is probably the worst from a resource management perspective. In the long-term it seems therefore that some form of cooperative management will be needed, as was recognized already in the Oslo B agreement. Yet by the time the damages of separate management will become apparent, much damage may be done to the detriment of both parties. Moreover, the greater the damage the greater the cooperation that will be needed to mitigate it. Actually, even the coordinated management structure established in the interim agreement was arguably insufficient. Thus, the two parties will probably need to discuss again cooperation options, regardless of the current impasse.

The main obstacle to greater cooperation is the loss of trust between the two parties. This loss pertains both to the existing coordination structure and to the good intentions and commitment of the other party to peaceful resolution of differences. At the same time, if and when the two parties will seek an area where agreements are feasible, which can be acceptable to wide domestic audiences, water may stand out as such an area. Thus, it seems likely that negotiations over water issues will resume at some point. However, they will be overshadowed by the loss of trust.

To overcome this impediment it is suggested that the confidence building measures identified by Haddad et al. be implemented. These include: changes in the way the institutions function and an augmentation of Palestinian water supply. However, such steps are likely to be insufficient. In particular, there will be a need to seek concurrently the cooperative structures that may be most appropriate for the current situation and that may be conducive for further agreements. It is suggested that structures based on third-party involvement may be particularly suitable for this purpose. In addition to their purported effectiveness, benefits may turn a two-party situation, where the two parties are highly suspicious of each other, into a three-party game, where the two parties share interests vis-à-vis the third party. However, to implement this type of structure, substantial preparatory work is needed.

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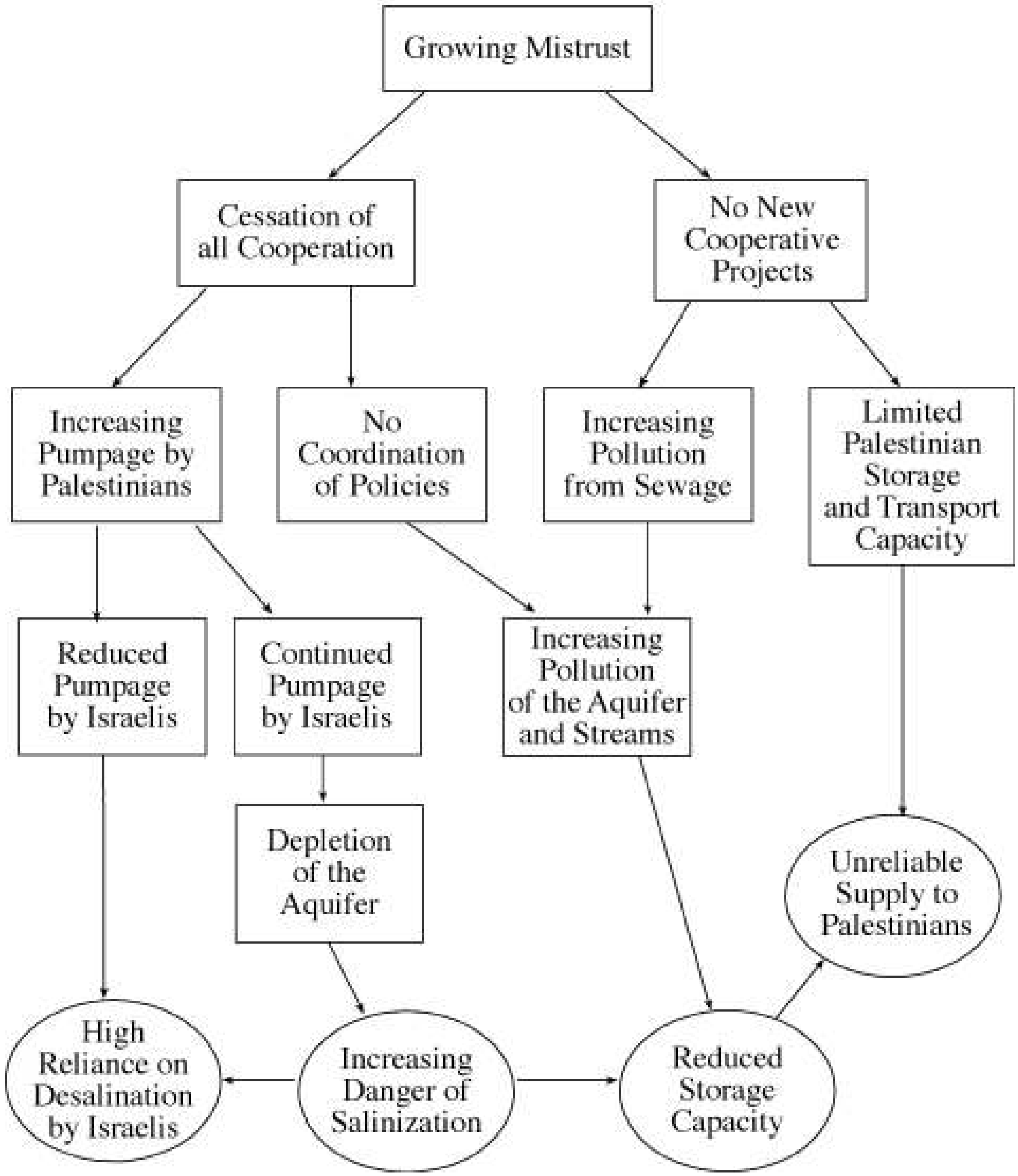
Figure 2: The Implications of Separation



[vii] Ibid, f.n. 5,

[xvii] For an exposition of this idea, see: E. Feitelson, 'Water rights within a water cycle framework, in: E. Feitelson and M. Haddad (eds.) *Management of Shared Groundwater Resources: The Israeli-Palestinian Case with an International Perspective*, (Boston/Dordrecht/London: Kluwer, 2001), pp. 395-405.

[xviii] This has been shown to be the case in the Israeli-Jordanian case, as has recently been shown by Itay Fischhendler, 'Legal and Institutional Adaptation to Climate Uncertainty: A Study of International Rivers', unpublished manuscript, 2003.

[xx] H. Gvirtzman, Israel water resources (Jerusalem: Yad Ben-Zvi, 2002, in Hebrew).

[xxiii] Ibid, f.n. 20.