אוניברסיטת בן-גוריון בנגב
NEGEV CENTER FOR REGIONAL DEVELOPMENT
מרכז הנגב לפיתוח אזורי
BEN-GURION UNIVERSITY OF THE NEGEV

WORKING PAPER No. 10

EVALUATING WATER BALANCES IN ISRAEL

Harvey Lithwick

Negev Center for Regional Development

With

Tilly Shames and Dovi Wilenski

December 1998

ISSN 0793-6780

THE NEGEV CENTER FOR REGIONAL DEVELOPMENT

The Negev Center was established in 1993 at Ben Gurion University of the Negev. The Center's main aim is to conduct action-oriented policy research and analysis, and provide up to date, professional information for planners, politicians, business people, scholars and the general public.

WORKING PAPER SERIES

As part of its promotion of policy-relevant research, the Negev Center for Regional Development has launched a working paper series, which aims to provide a rapid means of communicating research findings to the public.

The series aims to publicize the findings of research projects undertaken at, or funded by, the Center. It will also provide a publishing outlet for recent general research on Israeli urban and regional development issues.

The series will accept papers in Hebrew, English and Arabic. Papers will be made available to authorities, institutions, and interested individuals in Israel and abroad.

Correspondence for orders or submission of papers:
Dr. Oren Yiftachel
Negev Center for Regional Development
Ben Gurion University of the Negev
P.O. Box 653, Beer Sheva, Israel, 84105
Fax: 972-7-6278991; Email: yiftach@bgumail.bgu,ac.il

NEGEV CENTER FOR REGIONAL DEVELOPMENT

WORKING PAPER NO. 10

EVALUATING WATER BALANCES IN ISRAEL

Harvey Lithwick
Negev Center for Regional Development

With
Tilly Shames and Dovi Wilenski

December 1998

CONTENTS

ABSTRACT

This working paper examines the way in which Israel offers an interesting case study of how the understanding of a nation's water balances has evolved with improvements in technology, growing economic sophistication and internal and regional politics.

Over the past decade in particular, research in Israel has revealed that water issues are amenable to solutions based on the utilization of market forces. As a result, what was once viewed as an impending crisis has now been more realistically addressed as essentially an allocation problem, one that is not simple, but also one that is much less apocalyptic.

Furthermore, the potential for dealing with a variety of regional conflicts over water can be significantly enhanced with the strategic application of management and pricing regimes. As a result of such rethinking, there has been a radical revision in domestic policy with respect to water within Israel over this period, and it is to be hoped that the same sort of thinking will help contribute to alleviating long standing disagreements at the regional-international level.

EVALUATING WATER BALANCES IN ISRAEL

Harvey Lithwick
With Tilly Shames and Dovi Wilensky

INTRODUCTION

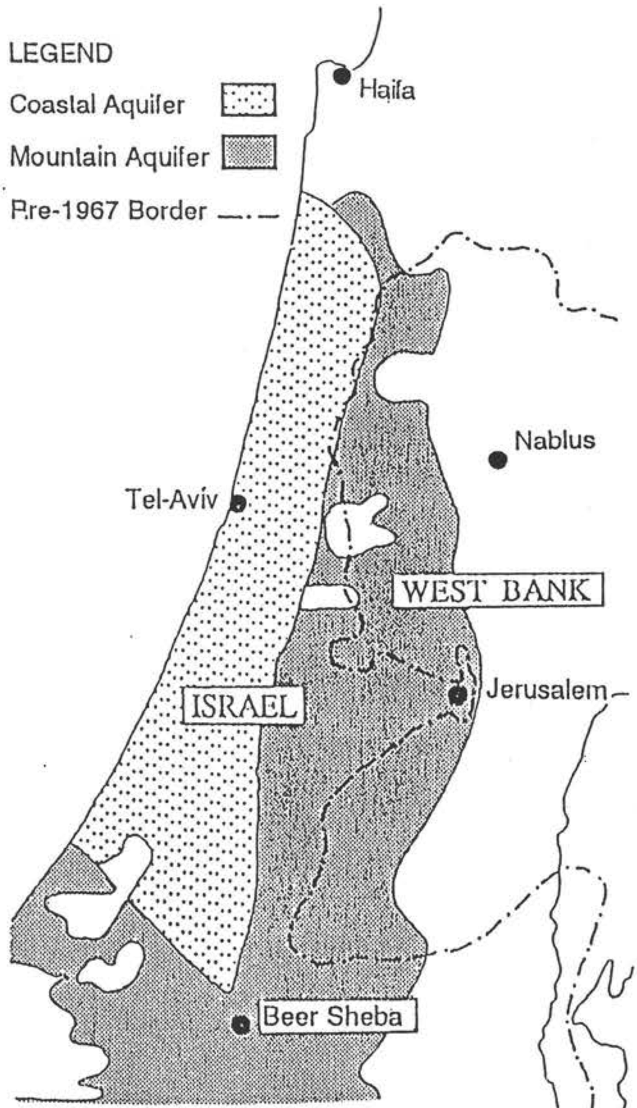
Israel provides an interesting case study of how the understanding of a nation's water balances has evolved with improvements in technology, growing economic sophistication and the evolution of internal and regional politics. In most circumstances, water balances have been viewed as exogenously determined – the difference between available sources and uses, both of which were deemed to be largely mechanistically predetermined. Over the past decade in particular, research in Israel has revealed that the issues are much more malleable, particularly with regard to the role of market forces. As a result, what was once viewed as an impending crisis has now been more realistically addressed as essentially an allocation problem, one that is not simple, but also one that is much less apocalyptic. Furthermore, the potential for dealing with a variety of regional conflicts over water can be significantly enhanced with the wise application of management and pricing regimes. Indeed, there has been a radical revision in domestic policy with respect to water within Israel over this period, and it is to be hoped that the same sort of thinking will help contribute to alleviating long standing disagreements at the regional-international level.

TRADITIONAL FACTORS SHAPING WATER BALANCES

The traditional approach to water was to focus on the quantitative "stock" of water, with particular attention paid to additions to and removals from the stock. The latter in particular were shaped by the allocative mechanisms, which in most countries reflect the interplay of powerful interests. We begin with a summary of this sort of water accounting in Israel. We then provide a brief overview of the historical background and conclude with a discussion of several currently salient issues.

The Entry Point: The Supply of Water

Israel has three major storage basins for its stock of water. One is rainwater and melting snow, primarily from Mt. Hermon, which enter the upper Jordan River and then flow into the Sea of Galilee. The other two are the coastal and mountain (Yarkon) aquifers (Fig. 1). These three sources account for almost two-thirds of Israel's current annual water supply of just under 2,000 MCM/YR. The rest is made up equally from smaller aquifers especially in the Western Galilee and the Arava/Negev region, and from recycled and brackish water. (Table 1).



OUTFLOWS, 1996:

Coastal Aquifer	418.1 MCM/YR
Mountain Aquifer	326.1
Sea of Galilee	512.4

Sources: Kliot, Map 3.7, p. 236
Government of Israel, Water in Israel, 1996, p. 15.

Fig. 1 Israel's Principal Water Supply Sources

	MCM/YR	% OF TOTAL
MAJOR SITES		
Sea of Galilee	512.4	27%
Coastal Aquifer	418.0	22%
Yarkon Aquifer	326.1	17%
Subtotal	1256.5	65%
OTHER SITES		
Negev/Arava	89.0	5%
Western Galilee	85.6	4%
Other	162.2	8%
Subtotal	336.8	17%
LOW QUALITY		
Dan Sewage Water	140.9	7%
Brackish	130.7	7%
Other	61.3	3%
Subtotal	332.9	17%
TOTAL	1926.2	100%

Source: Gov't of Israel, Water in Israel, 1996, 18.

Table 1. Sources of Water Supplies in Israel, 1996

These sources are dependent primarily on annual additions through rainfall. This entry point is problematical on a variety of grounds, most important being short-term climatic variability, and the possibility of longer-term periods of significant declines in the form of epochs of drought. The Sea of Galilee has had annual inflows ranging from a low of 100 MCM in drought years (most recently 1991) to a high of 1500 MCM. (Kliot, 237) These phenomena impose on planners the need to make appropriate risk allowances in estimating future requirements.

On the other hand, only part of the inflow manages to find its way into the water supply. Evaporation from the Sea of Galilee amounts to over one-third of its annual inflow (Table 2). Also losses due to leaky pipes, especially in urban areas have been estimated at about 5% of the total annual production. In some cities, it has been estimated that up to 50% of the supply may be lost due to such leaks. (Kliot, 239).

In Israel, there are long standing stocks of water in the fossil desert aquifers (under the Negev and Sinai), which at present provide some 30 MCM/YR but are estimated to be able to provide several hundreds of MCM/YR (Issar, 1998). However, these stocks are not rechargeable so that draws on them are essentially non-reversible, which may explain in part why this source has not really been exploited.

The National Water Carrier, one of Israel's most important infrastructure projects, carries a very large proportion of Israel's water supply to users from the north of the country down to the northern Negev. (Fig. 2).

Finally, there has been increased effort to re-use water, that is, putting the water that has been used back into the stock. This entails a lower level of water quality, which affects the allocation process, a subject to which we shall return below. In fact, this has been the major "new" source of water in Israel. Total sewage water produced in Israel amounted to 453 MCM/YR in 1990. At that time, just over one-third was treated for use as irrigation water. Plans are to increase the volume of treated water to be used for irrigation to 292 MCM by the year 2000. (Kliot, 239).

Eckstein has provided more comprehensive estimates of Israel's <u>potential</u> water supply by source:

⇒ Underground reservoirs	1250 MCM/YR
⇒ Jordan and Sea of Galilee	640
⇒ Lower Jordan/Yarmuk	85
⇒ Streams and springs	130
⇒ Treated Waste Water	460
TOTAL	2,570

Major Source	MCM/YR	Period	Consequence
Sea of Galilee			
Effective Stock	600		
Inflows			
Jordan River	494	1980-1985	
Runoff	216		
Precipitation	65		
Other	37		
Subtotal	812		
Outflows			
Evaporation	294		
Downstream	42		
Into Water Supply	500		
Subtotal	836		
Net Flows	-24		Consequence, salinity, lowering level
Coastal Plain Aquifer			
Effective Stock	320		
Net Flows	-96		Consequence, pollution, salinity
Mountain Aquifer			
Inflows			
Precipitation	350		
Negev Aquifer			
Outflow	30		

Source: Kliot

Table 2. Key Storage Basins for Groundwater, to 1995

Source: Kliot, Map 3.6, p. 215.

Fig. 2 The National Water Carrier and Related Water Products

It should be added that most of these water sources are under dispute with Jordan, Syria and the Palestinian authority. (Fisher). A rough estimate of the amount of annual water flow under dispute is:

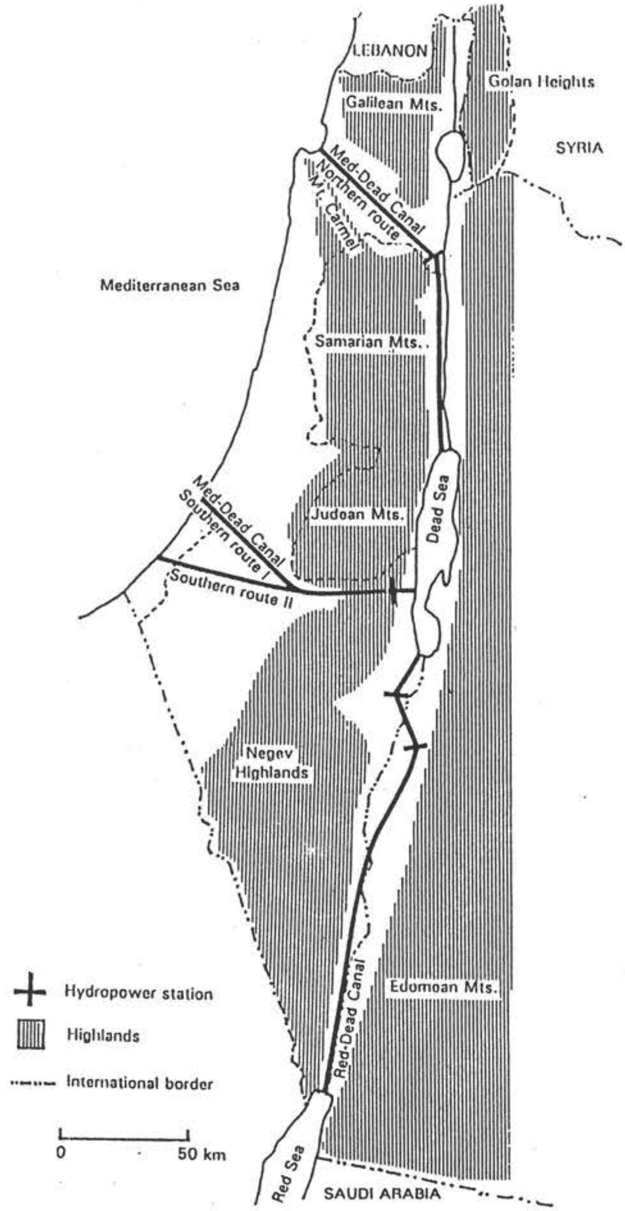
⇒ Jordan	600 MCM/YR
⇒ Yarmuk	500 (250 MCM flows south of Syria)
⇒ Mountain Aquifer	600

Traditional practice has been to search for new water sources to deal with the perceived shortages, and a number of schemes have been advanced over the years. There remains very active debate about their project or capital costs, operating costs, and of course, the security of supply. Only a brief review of these schemes is possible here. The following is a summary of their key characteristics, and where appropriate, estimated costs (per cubic meter, CM).

- ⇒ More intensive use of brackish waters, already being implemented.
- ⇒ More intensive capturing of rainwater (potential of up to 160 MCM/YR.). Includes use of microdams (Laronne).
- ⇒ Desalination of seawater (estimated cost: $0.80 – 1.00, 1992 prices).
- ⇒ Importation of water, from the Litani River in Lebanon (geopolitical constraints).
- ⇒ Importation of water from the new Manavgat depot in southern Turkey, by sea. (Costs have been estimated to be above those for desalination. James Cran, the proponent of the Medusa Bag technique, involving towed chains of plastic bags filled with water, estimates the cost of this solution to be $0.18 per MCM, but this is far below the price that the Turkish authorities wish to charge – See Nachmani, p. 26).
- ⇒ Importation of water from Turkey, overland, via Syria and the peace canal. See Wachtel. (not costed, and with major geopolitical constraints).
- ⇒ Importation (via Canal) of Nile water to Gaza and the Negev. ($0.40 but geopolitical constraints).
- ⇒ Canals to link the Mediterranean or the Red Sea to the Dead Sea (Fig. 3). The estimated costs excluding delivery range from $1.00 to 2.00 (Bar-El).

While widely used as the basis for choosing between alternatives, such cost comparisons do not even constitute cost-effectiveness evaluations. At best, these calculations estimate direct costs, with little attention to accounting explicitly for external benefits and costs, and they would appear to use widely varying discount rates, etc. To the best of our knowledge, no systematic social cost benefit analysis, (CBA) the appropriate project analysis tool for such comparisons, has been undertaken.

It should be stressed that the availability of alternative supplies at different costs makes the aggregate supply curve of water a rising step function, rather than a vertical one, as is commonly claimed. The highest relevant cost is generally believed to be that of desalination – it will likely dominate all other major proposed sources in the next few decades. There is some dispute as to <u>when</u> it will become an effective option, however. The Harvard team headed by Fisher concluded that compared to currently available alternatives, the desalination option would not likely become viable until the year 2020. Shadow prices of water on the Mediterranean coast, where such plants would be located, are not expected to rise above $0.70



Source: Hillel, Fig. 11.10.

Fig. 3 Proposed Canal Projects

in 1990 prices until that date. The other canal projects are more expensive and hence are dominated by the coastal desalination alternative. (Fisher, 387).

b. The Utilization Stage. The Demand for Water

The dominant user of water in Israel is the agricultural sector. Despite the relative decline of the sector, from 11% to 5% of GNP since the founding of the state, and, as a share of exports, from 60% to 4%, it has grown significantly in absolute terms with important implications for overall water use. Area under cultivation has almost tripled from 0.4 million acres to 1.1 million, while the amount of irrigated farmland increased 9 times, from 0.07 million acres to 0.63. On the other hand, new techniques have lowered the water use per acre by one-third. Nevertheless, agriculture still accounts for about 64% of all water consumed. (MEWIN, 1998). Of this, kibbutzim consumed 44% and moshavim, 33%. (Lindholm, 62). The strong political organization of these entities obviously plays an important role in influencing the mode and levels of allocation. By contrast, the share of domestic and urban use stands at about 30% and of industry, at 6%. (Government of Israel, Water in Israel, 1996, p. 4).

The prices charged to users have always reflected a bias towards subsidizing water-intensive agriculture. At present, the price continues to differ by up to a factor of two. Not only does this influence the allocation of water among users, but the overall rate of utilization of water as well. The most recent average prices we have found are as follows (for October 1996, since raised):

	1996 Rates		Eckstein est.1992
	NIS	$US	Actual $US
Agriculture	0.62	0.19	0.17
Industry	0.83	0.26	0.11
Domestic	1.12	0.35	0.50 to 1.22
Wastewater	0.50	0.16	

(Exchange rate in 1996 = 3.2 NIS per $1 US)

For efficient pricing, users should pay the marginal social cost of water delivered to their particular location. The marginal direct cost averages about $0.35 per CM. This means that there is a major subsidization of agricultural and industrial use by the domestic sector, as well as by taxpayers, which provided an overall subsidy of some $200-250 million for water use in 1990. (Kliot, 239) A major reason for these cross and overall subsidies is that in Israel, the allocation of water and investment in water projects is controlled by a politically responsive state monopoly, which ensures inefficient allocation of water supplies. We will elaborate on this issue in the following section.

Recent estimates project the annual growth in demand for water in Israel at a rate of about 30 MCM/YR, mostly due to urban and industrial expansion. However, the official projections, particularly those of TAHAL have had to be subjected to some upward revisions because of changes that had to be made to their underlying assumptions. The most systematic of the revised estimates until recently were those of Eckstein et. al.

For the household sector, they take into account the more rapid growth of population as a result of the wave of immigration from the former Soviet Union. This adds some 700,000 to the original population estimates. They also add a higher growth rate for the Palestinian population. This leads to an increase in household consumption by 39 MCM in 1990 and 52 MCM by 2010.

For manufacturing, most demand is concentrated in food, quarrying and chemical industries, much of which is located in the south of the country. However, other than in the West Bank and Gaza, there is little basis for expecting rapid growth in the industrial use of water.

For agriculture, the estimates of use should be based on price assumptions. TAHAL had stuck to quantitative estimates, albeit implicitly reflecting an acceptance of higher prices, projecting a decline in quotas for agriculture that amounted to between 17 and 25% in total, and 55% for fresh water. This would be offset to some extent by an increase in agricultural consumption in the West Bank.

Naturally there is serious concern over the net balance between inflows and outflows, discussed above, because over time, continued net withdrawals (or deficits) will deplete the stock or render it less usable due to qualitative deterioration. Kliot has estimated these accumulated net deficits up to 1990 (Table 3). These net flows should be seen in the larger context of the existing stock to provide perspective on the nature and extent of the problem. One such attempt to estimate the relationship between stocks and flows at one key site in Israel – the Sea of Galilee - is summarized in Annex 1. It can be seen that net annual flows constitute between 12 and 14% of the total stock of water in the lake. This is not to imply that the whole stock is available for extraction at any time of severe shortage, since depletion below some red line will cause severe environmental damage to the lake and the lakeshore. In recent years, the level has receded very close to that red line and hence there is legitimate concern over any annual deficit.

c. The Politics of the Water Allocation Process

Out of the stock of water, decisions must be made regarding the allocation of these supplies among various domestic users, which includes both the types of use (agriculture, industrial and residential) and the locations of the users. Such allocations always reflect political considerations together with economic realities. But whereas allocation based on economic considerations tends to promote efficiency in both the production and consumption of water, and on the efficacy of major new water project investments, other modes do not. And in Israel, economic considerations long played a secondary role, exacerbating thereby the scarcity problem. However, over the past decade, Israel has managed to make some substantial progress in achieving water reallocation away from agriculture and towards other uses yielding higher returns.

SOURCE	NET OUTFLOW	OVERUTILIZATION	ACCUM. DEFICIT
Underground			
1.Coastal Aquifer	240-455	34-80 (1980-90)	100-1400
2. Local Aquifers	23-280		Small
3. Mountain Aquifer	300-330	50 (1980-90)	300-350
Surface			
4. Sea of Galilee	575-950	25 (1980-85)	140
5. Floods and Treated Sewage	200-230		
TOTAL	1890-2311		1570
Water Losses	60-100		
BALANCE	1790		

Source: Kliot, Table 3.13

Table 3. Stocks and Flows of Water from Major Sources, to 1990

There is an interesting semantic phenomenon, referring to use of water by various sectors as "demand". Economists are aware that demand measures the amounts that consumers would like to purchase at alternative prices – but most of the forecasts of demand appear to be based on quantitative extrapolations, ignoring or at best underestimating price and income effects. The consequence is that if prices charged are substantially below their true competitive equilibrium, the estimated quantities demanded and hence utilized will be much higher than that which is economically efficient and socially optimal.

Water is, for most purposes, what economists call an intermediate input. As such, other than for household use, its value is based not on the utility derived from direct consumption of the water itself, but on the value of the goods and services it helps produce. If the outputs are valued in competitive markets, the value of the water can readily be estimated. Where they are not, such as in highly protected agricultural markets, the value of water is more difficult to measure and must be derived through shadow pricing. It has been estimated that the value of the marginal product of one cubic meter of water in agriculture is between $.15 and .30 (Arlosoroff). Economic rationale would therefore allocate water to such a use if its delivered cost were less than its value. Since the delivered cost is a function of location the net effect would be to reduce water use for agriculture in remote regions. Similarly, it would tend to reduce the production of those crops whose value per unit of water used was relatively low. Clearly this would affect a wide variety of agricultural interests.

While reduced consumption is therefore an appropriate goal, all to often it is promoted by the public sector advocating specific technologies. Appropriate pricing is a preferred alternative, as it will encourage the most cost-effective technologies to be introduced at the appropriate time within the various sectors. However, the dominant users of water in the agricultural sector, represented by The Association of Farmers, have resisted such a policy orientation for perhaps obvious reasons.

To the extent that the allocation process is based on non-economic considerations, therefore, it is very likely that the use will bear very limited relationship to overall community valuations and to real resource costs. That is not to argue that political considerations are not important – security of food and energy supplies for a security-conscious state like Israel are indeed of great importance. But it may well be that misallocations of water actually contribute to greater rather than less insecurity by wasting a relatively scarce resource, and making peaceful solutions to interregional water disputes more rather than less difficult. Recent attempts to impose more rigorous cost and price discipline should go a long way in encouraging more efficient use. (Arlosoroff). Over the long run, efficient pricing also ensures that investments made to produce and utilize water are also efficient.

CALCULATIONS OF WATER'S SCARCITY VALUE IN ISRAEL

In Israel, reallocation of water use is being achieved in the face of these long-standing interests, in large part as a result of the accumulation of evidence on the costs and benefits from water utilization.

It is useful to begin with extraction costs. Quantities and costs of extraction (1992 prices) from other sources (common pool) are as follows: (Eckstein)

	Quantity MCM	Price $US	Conflicts
Southern coast aquifer	49	$0.42	Gaza
Yarkon aquifer, north	90	0.14	
Yarkon aquifer, south	110	0.20	
Gilboa	131	0.31	
Sdom, Dead Sea	84	0.12	
Ramallah	25	0.57	West Bank

As for the aggregate supply prices of water, the marginal costs of extracting water have been estimated by Bental, and they are presented in Table 4.

QUANTITY	MARGINAL COST	
(MCM/YR)	1991 NIS	$US
0	0.34	0.15
700	0.46	0.20
1100	0.68	0.30
1400	0.91	0.40
1700	1.25	0.54
1900	1.60	0.70
2000	1.82	0.79

Note: Exchange Rate 2.3 NIS per $1 US.
Source: Bental, Table 11.

Table 4. Marginal Water Extraction Costs

Based on the cost of water from the mountain aquifer, of some $0.50 per CM (Eckstein), some important orders of magnitude of the benefits to be derived have been estimated. If this represents the efficient price of water, then the value of the estimated 2000 MCM used per year is about $1 billion, or 1.7% of the GDP of the entire region. For a highly efficient water use regime to emerge, the allocation would have to change dramatically. Water in the northern Negev (and Gaza) costs about twice as much as in the Galilee. The efficient use of the water would require a 10% cut in the north, and a 40% cut in the south, mostly in agriculture and primarily for marginal crops which have a very low value added per unit of water input. The study estimates that if water were priced based on efficient allocation, total water consumption would have fallen by 296 MCM in 1992, to 1779 MCM or by 16%. The price of water would rise by $0.30 and the quantity used in agriculture would fall by 10-15%. The price of water in the south would have risen 170% and the quantity used in agriculture would have fallen by 25-30%. Based on this evidence, the current efforts to move major amounts of agriculture to the Negev appear to be extremely ill considered.

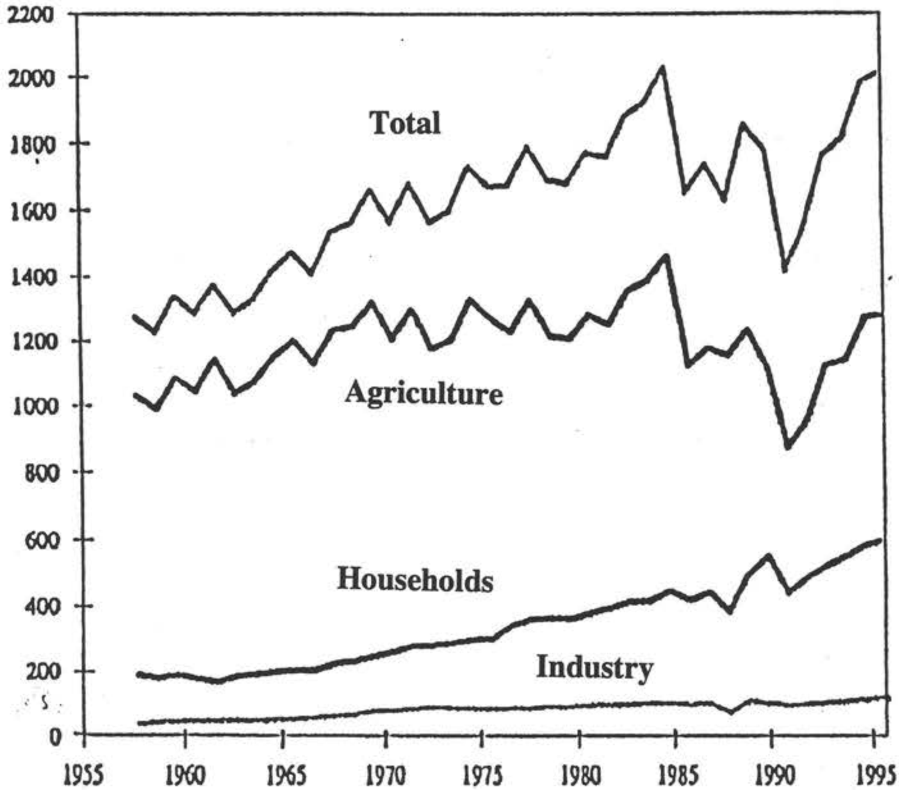
An important study by Gideon Fishelson at Tel-Aviv University in 1993 provided the first set of elasticity estimates for household demand. He estimated the (long-term) income elasticity to lie between 0.2 and 0.4. The price elasticity was estimated to be between –0.05 and –0.15. Based on these relatively low elasticities, the author argues that even at very high prices, there will be very little likelihood of household consumption declining below the bench mark current consumption of 110 CM/YR.

HISTORICAL TRENDS AND RECENT ESTIMATES

The long term trends in water balances since the late 1950s reveal that the agricultural demands which grew steadily until 1983 declined dramatically - by almost a third - until 1990, but have sharply reversed that trend during the first half of the current decade. It is the domestic sector that has undergone steady long-term growth, offsetting whatever savings were realized in agriculture over the past decade. (Fig. 4). We should note, however, that on a per capita basis, there has been a substantial decline in overall water consumption in Israel (Fig. 5), no doubt in large part due to the slowdown in agricultural consumption since the mid-1980s.

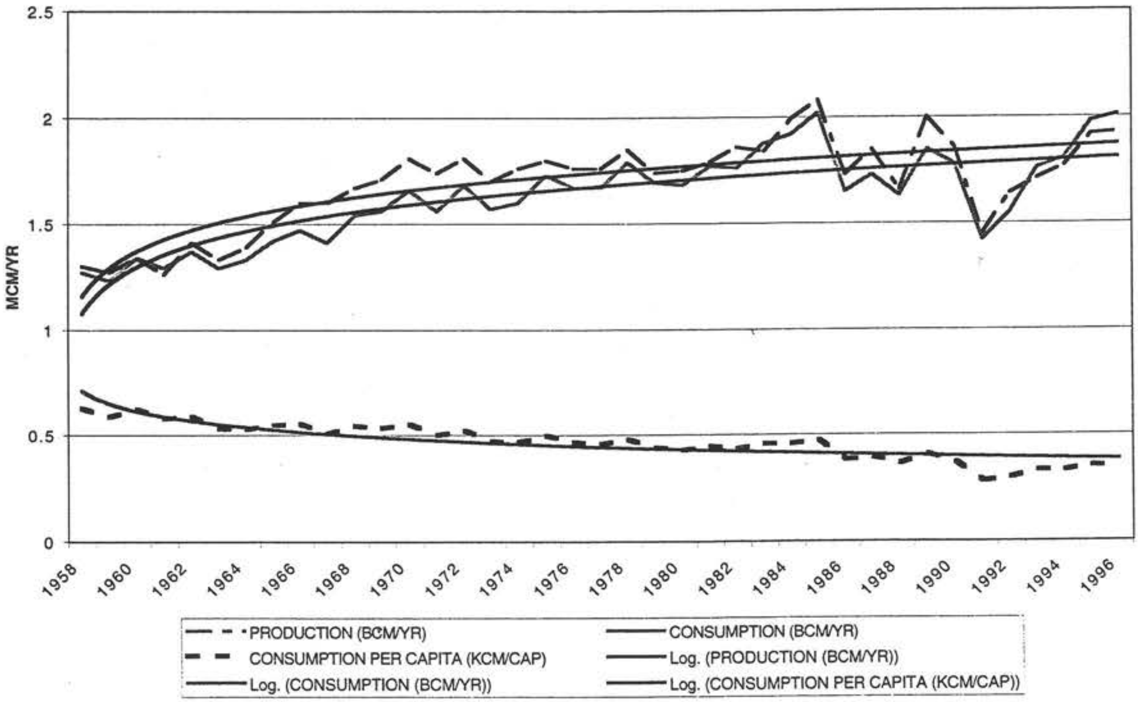
Table 5 presents the most recent estimates of water balances in Israel, projected to the year 2040. They represent a major improvement in water allocation planning, with the estimates based on more realistic projections of demand, supplies, and the use of efficiency based allocation procedures. Overall, these procedures have granted Israel a period of perhaps a decade in which to find more fundamental solutions to its long-term water requirements. Since developing these solutions take a number of years, it would appear to be a matter of some urgency to begin the planning in the very near future. Ideally, a combination of approaches should be considered, to avoid undue reliance on one technology. For example, a ten-year contract to deliver Turkish water, coupled with the development of pilot desalination plants on the Mediterranean could be considered, after appropriate social cost benefit analyses, have been conducted.

MCM/YR



Source: Government of Israel, Water in Israel, 1996, p. 12.

Fig. 4 Historical Trends in Water Use (mcm/yr)



Source: Government of Israel, Water in Israel, 1996, pp. 11, 20.

Fig. 5 Historical Trends in Production and Consumption of Water in Israel

		1990	2000	2010	2020	2040
Annual Inflows						
Israel and West Bank	Groundwater	1060	1090	1100	1100	1100
	Jordan Basin	660	670	670	670	670
	Floodwater	40	50	70	80	70
	Losses	-40	-40	-30	-25	-25
	Subtotal	1720	1770	1810	1825	1815
	Reused water	198	296	418	651	1071
	TOTAL	1918	2066	2228	2476	2886
Annual Outflows						
Israel	Municipal	481	654	774	915	1151
	Industrial	106	130	155	183	255
	Irrigation	1200	1200	1200	1370	1920
	Subtotal	1787	1984	2129	2468	3326
West Bank	Municipal	36	71	133	204	379
	Irrigation	100	155	190	280	300
	Subtotal	136	226	323	484	679
Gaza Net Use		43	43	69	94	147
	TOTAL	1966	2253	2521	3046	4152
NET FLOWS ISRAEL AND WEST BANK		-48	-187	-293	-570	-1266

Source: Israel Water Study for the World Bank, reported in
Government of Israel, Partnership in Development, 1998, Nov. 1997, Chapter 2.

Table 5. Israel's Current and Projected Water Balances

WATER: A HETEROGENEOUS PRODUCT

We have to this point assumed that water is a homogeneous product, but one of the factors which complicates the story of water use is that it can and does exist at different levels of quality. And some of the uses to which it may be put do not require the highest level. Clearly, a system that optimizes water use will attempt to allocate such quality-differentiated supplies in the least cost manner, a process that is already underway in Israel, but one which, for perhaps understandable reasons, encounters significant resistance. For example, because of extremely high standards for drinking water, all water that is delivered to households must meet these standards. But water for direct consumption constitutes a miniscule portion of total household water needs. Methods to encourage alternative modes of delivering drinking water could conceivably reduce significantly the quality and hence cost of household water. Also, encouragement of direct household recycling of "gray" water for garden use would promote important efficiencies.

The allocation implicit in the Telem study for TAHAL in 1988 was based on similar considerations. The plan was to reduce fresh water consumption from 1800 MCM/YR to 1600. The household demand for fresh water would rise by 480 MCM while that going to agriculture would fall by some 660 MCM. Recycled water would be allocated in much greater amounts to the agricultural sector, both as a substitute for the lost fresh water, and to enable further expansion. The current distribution of water by quality level among users is provided in Table 6, and it indicates that the targets have been achieved.

ISRAEL'S WATER MANAGEMENT SYSTEM

Israel's stock of water is managed by a complex set of relationships among three distinct bodies. TAHAL is the agency originally charged with the strategic planning of water policy, as well as hydrological research. TAHAL has recently been privatized and the Planning Branch of the Water Commission now conducts its former planning function. The Water Commission is responsible for setting and implementing water policy. It was historically attached to the Ministry of Agriculture, but has been moved to the Ministry for National Infrastructure. It is hoped by many that this move will weaken the disproportionate influence of the agriculture sector on water policy. Finally, Mekorot, the Israel National Water Company, is the agency that is in charge of the wholesale supply of water to urban communities, industries, and irrigation users. It supplied 1,350 MCM of water in 1995, or 70% of the total supply, of which 60% was for agricultural use, and 40% for industrial use. Fifty MCM were used to replenish overpumped aquifers. Its major piece of infrastructure, the National Water Carrier, conveyed some 370 MCM of water from the Sea of Galilee as far south as the Beer Sheva region in the Negev. Table 6 provides more detailed information on the relative significance of Mekorot in the total water supply system.

In recent years, Mekorot has taken over operation and management of local water utilities and sewage treatment facilities. Its monopoly power is problematic, and recently there have been

USE	Fresh Water	Effluents	Brackish	Total	Mekorot Share	Mekorot %
Agriculture	898	227	86	1211	747	62%
Domestic	578		2	580	444	77%
Industrial	111		25	136	94	69%
TOTAL	1587	227	113	1927	1285	67%

Source: Arlosoroff.

Table 6. Water Use by User and Water Quality Level, 1995

proposals to inject more competition via encouraging local authorities to run their own facilities, and precluding Mekorot from entering the desalination program of the future.

Clearly many of the functions among these agencies overlap, which led in the past to problems of authority and accountability. To this date, the Water Commission's functions are split among various ministries, further eroding coherent and responsible planning. There are proposals before the Knesset to reduce, via privatization and devolution to local governments, the direct role of the central government in maintenance of the water system together with its conveyance, and the treatment and disposal of effluents. The national government's role would thereby be more sharply focused on regulation and monitoring, and determining extraction licenses and quotas. Preferably it would operate through market mechanisms, which would yield a significant gain in efficiency in the whole sector. Ideally, water would be priced at its social marginal cost, reflecting its true scarcity value.

THE ROLE OF TECHNOLOGY AND ECONOMICS

A key question is, what is the value of water to the Israeli economy? Using the price of desalination as the maximum willingness to pay, and the shadow (efficient allocation) price of $0.50, the net value of the common pool available is estimated to be some $200 million per year, or less than half of one percent of Israel's GDP (Eckstein). The net rents from the common pool are slightly less than $100 million, which could serve as the basis for financing water projects.

The scale of desalination to date is modest. Most of the plants are in the remote Eilat area, meeting more than half of that city's needs. As we have seen, in other parts of the country, the process is not cost effective, nor does it appear likely to be so in the near future.

Efforts to enhance rainfall through seeding clouds with silver oxide crystals have been conducted over the Sea of Galilee for the past two decades. The result has been an increase in annual rainfall in that area by almost 20%.

Existing water supplies can be "augmented" through the use of new technologies, as Israel has demonstrated in numerous fields. On the one hand, improvements in drilling techniques have made once inaccessible stocks an important component of annual supply. On the other, micro-sprinklers and then drip irrigation with computerized control systems have made much more efficient use of existing water supplies. Up to 20% of water loss has been reduced by these methods. New technologies for using brackish water for agriculture without diminishing yields have had beneficial impacts as well.

A major new source of water is treated household and industrial effluents. Over 100 CM/YR from this source now are being used in agriculture (cotton and fruit growing), but another 200 CM are discharged into groundwater or the sea due to the absence of storage facilities.

A decade old program involves building artificial lakes (120 to date) which collect surplus winter runoff. The water in these lakes can be used not only for irrigation, but also for recharging aquifers and storing water in transit between uses and locations. How these innovations came about – the result of responses to scarcity signaled at least in part through rising prices – remains to be fully analyzed. Certainly, the subsidization of many uses retarded such innovative processes, and it is expected that recent reforms will give much freer rein to imaginative solutions.

An alternative means of augmenting water supplies is through importation, rather than production of especially water intensive, low value-added food supplies. With the opening of global food markets, and intense competition among suppliers, countries in the region, such as Egypt, have been able to forestall a potential water crisis through imports. For decades Israel followed the opposite path, by subsidizing via the price of water, agricultural production and exports, effectively encouraging the export of water (Allen, 1998). By shifting to food imports and more carefully allocating water supplies, especially to high cost locations, and avoiding crops with low value added per unit of water input, the overall social impact of an increase in the price of water towards its true scarcity value can be substantially mitigated.

The other side of this coin is less comforting. Improved agricultural techniques, such as the use of fertilizers and insecticides, which in part permit agriculture to make do with less water, contribute to the reduction of water quality. Kliot reports that, according to the Water Commissioner, most of the water for the domestic sector is below the official quality standard, especially with regard to nitrate content which is also above the internationally accepted standard. (238). The most severe effects from overpumping due to shortages have occurred in Gaza, where the level of contamination of the groundwater is extremely high (244).

Furthermore, Mekorot's distribution system is very energy intensive, accounting for over one-quarter of the company's operating costs, and using 8% of the power generated by the Israel Electric Corporation. One suspects that the associated environmental costs (air pollution) thus attributable to water provision are not yet being factored into its price. Offsetting this is the fact that with the increased use of treated effluent water for agriculture, fewer pollutants enter urban streams and the sea, reducing the already alarming levels of environmental damage with its high social costs in those dense areas. Groundwater is being affected in the rural areas that use such water supplies, but lower densities of population in rural areas will tend to reduce the net social cost of this transfer.

Partially in response to the perceived environmental, energy and water problems, Prof. Dan Zaslavsky, a former Water Commissioner, has been proposing a new technology called "Water Towers", which, he argues, can effectively produce electric power and water in desert areas. Whether or not this technology is economically feasible remains to be seen, but it does reflect the kind of imaginative search for new technologies that Israel requires at this juncture, and which has been encouraged by the move to more appropriate pricing of water.

In recent years, attempts to restock aquifers and improve water quality have led to a diversion of water for that purpose. Between 1983 and 1988, between 54 and 122 MCM/YR were pumped into the coastal aquifer, and 150-200 MCM/YR into the mountain aquifer. (Kliot, 238).

THE ROLE OF GEOPOLITICS

The geopolitical importance of water is well known. Aaron Wolf points out that the Jordan River basin poses two problems: 1) a water crisis in which the supply of water does not meet demand; and, partly in consequence, 2) a water conflict, involving competition for these relatively scarce supplies by riparian nations who have deep and long standing enmity towards each other (Wolf 1995). The Jordan River Basin is therefore at a crossroads in which water has the potential to lead to either cooperation or conflict. The former will emerge if there are enhanced water resources for the region to share, and the latter if each side sees the issue as a static zero-sum game, leading to tension, possibly conflict and precluding water development for the future.

The core problem facing Israel is that its major surface water source (the Jordan River) and its underground water sources (the two aquifer systems) are also claimed by other jurisdictions. The Jordan River is a complex system of sources and distribution, as can be seen in the schematic presented in Annex 2. The two major actors are Israel and Jordan. The Palestinians are involved primarily in the aquifers that are adjacent to their territories adding a second dimension to the debate.

These inter-country conflicts can be broken down into two distinct issues: a) the issue of property rights, which pose no particular problem of efficient allocation and use if the water is correctly priced and rights are freely traded; and b) the issue of externalities, which requires a common management system to ensure efficient allocation.

For a common management system to be completely effective, it must involve all actors with an interest in and ability to affect the system. Cooperation must take place in the form of joint action plans, joint commissions, and joint treaties, based on a regional approach to watershed planning involving all riparian states and regional actors with an interest in the water source. In the case of Israel and her neighbors, this requires basin-wide cooperation, involving, in addition to herself, Jordan, Syrian, Lebanon and the Palestinians. The Treaty of Peace, 1994, between Israel and Jordan provided for a division of water resources without the involvement of the other riparian states. Therefore, the supply of water to be affected by this agreement could be diminished, and joint cooperative plans under development could be derailed, by other parties with access to and an interest in this water source.

Is Israel capable of and willing to approach the management, distribution and allocation of these shared water resources? Any sharing of water will be seen as reducing its ability to meet its own water needs even if it entails infringing on the rights of others to meet their own needs. Israel is in a unique position of having a great deal of control over the distribution of both underground and surface sources, which affect its neighbors. However, it remains potentially highly vulnerable to the actions of the other riparians. Israel is heavily dependent on two contested sources: 430 MCM/YR it receives from the mountain aquifer, and an additional 305 MCM/YR of fresh renewable water from the Golan, totaling 735 MCM/year of Israel's 1,587 MCM/YR total fresh water consumption (see Table 6). The mountain aquifer poses a greater challenge. Palestinians are unable to expand their own water resources in this region. Extensive groundwater development in these territories would threaten coastal wells due to increased saltwater intrusion from the sea (Wolf 1995). Moreover, any pollution of this underground source of water will result in a net loss of water available for Israel's population. Therefore, in order to protect its scarce sources of water, Israel believes it needs to control groundwater exploitation and prevent contamination in the West Bank territories.

Despite the many innovations noted above, it is far from certain that the long-term water needs of the region will be met as demands continue to expand. To date, in the absence of frameworks for cooperative action, innovations have been made based on narrow, inward-looking grounds. For example, Jordan constructed its East Ghor Main Canal (EGMC) system, which runs along the east coast of the Jordan River, to serve agricultural needs of the country, while Israel developed its National Water Carrier, starting at the Sea of Galilee and channeling water throughout the country. These and other initiatives began to interact, resulting in growing tension. The War of 1967 is a key example of escalated tension leading to conflict. The inclusion of water issues in the multilateral talks related to the Israeli-Palestinian peace negotiations highlights the importance of this issue to the future development of this region and the resolution of conflict.

The potential for cooperation is certainly there. In addition to non-conventional water resources that can be developed unilaterally, there is scope, especially with Jordan, for joint research and innovation programs. Moreover, short-term water needs can be alleviated by inter-basin transfers of water. Options include diverting water from the Litani to the Sea of Galilee, (providing 100 MCM/YR to Israel, Jordan and the West Bank); from the Nile to the Jordan Watershed, (resulting in 500MCM/YR; and from Turkey to the Jordan Watershed, by pipeline (1,100 MCM/YR) or Medusa bags (500 MCM/YR) (See Annex 3). Longer-term cooperation could focus on regional initiatives, such as desalination projects.

The degree to which these projects are possible depends on the willingness of these states to cooperate for the sake of enhancing water resources to meet the water needs of the region as a whole. The combination of a need for expanded water sources, and a dependence on shared water sources, should provide a powerful incentive for cooperation. A peaceful resolution of conflict in this region will increase the chances of successful implementation of the proposed projects. At the same time, pursuing these initiatives may encourage further dialogue and cooperation among riparian actors. As such, cooperation over water may contribute to and benefit from an environment of peace.

WATER AS A SYMBOL

Perhaps the greatest barrier facing rational national and regional solutions to the so-called Middle-East water crisis is the symbolism attached to the resource. In Israel, it is intimately bound up with the early Zionist views about land and the importance of agriculture in settling and claiming it.

> *"Water for us is life itself. It is food for the people, and not food alone. Without large-scale irrigation ... we shall not be a people rooted in the land, secure in its existence and stable in its character."*
>
> (PM Moshe Sharret, 1952, quoted in Feitelson and Haddad, 1994, p. 73)

Those views persist to this day in the subsidizing of water for agriculture, imposing costs on other users, as well as on the economy as a whole in terms of wasted resources. That approach, focusing on quantities alone, has led many to conclude that current rates of overuse are plunging the region into a crisis. Such a view has been justifiably ridiculed by no less an authority than a former Israeli water commissioner, Dan Zaslavsky, who points out that "There are local and temporary shortages because it's not the highest priority of the countries involved; that's all..." (quoted by Nachmani). The traditional view is changing however, and more rational allocations, using more appropriate prices and water quality mixes, are emerging on the part of the water authorities themselves.

Just one of the adjustment mechanisms has been stressed by Allan (1998a), namely importing of "virtual water" at low cost in the form of food products from region's which have a comparative advantage in water. Another is the major reduction in water use in Israel, from 2000 MCM/YR in the mid-1980s to under 1600 in less than a decade, primarily through the increase in productivity in agriculture, occasioned by higher prices reflecting growing scarcity. (Allen, 1998a). Unfortunately, the update on that story is a bit less optimistic, as the last few years have seen a sharper increase than was anticipated, with total consumption in 1996 approaching the 2,000 MCM/YR level once again.
(Fig. 4).

On a regional basis, issues of sovereignty enter, and water has been at the center of major, long standing disputes. Once again, too much focus has been on quantities, and allocating them among the various states which have conflicting claims. But these huge claims are based on existing patterns of allocation, which fail to allocate water in terms of its scarcity value (shadow price). Such a view is strongly expressed by Nachmani. In other words, few dare to question the demands or needs being claimed, which are necessarily exaggerated because use is priced below true scarcity value. Allan goes so far as to claim that in the Middle East, "water almost everywhere is treated as a free good". (1995, 344). Moreover, as Fisher and others have shown, the implicit value of the water in conflict is surprisingly small, and appropriate solutions are feasible. The value of this water is estimated by Fisher to be no more than $110 million, rising to some $500 million in 1990 prices by the year 2010

Of course this argument ignores the possibility that water may not be the cause, but the symptom of more basic conflicts, so that managerial-economic solutions are beside the point. Nevertheless, a less symbolic approach to water has helped Israel achieve substantial efficiency gains in its domestic water use, and a similar approach applied regionally may offer some hope for collective action at that level.

PROSPECTS

Israel has obtained a modest window of opportunity with which to deal with its own and the region's water needs. By moving towards a policy of efficient allocation, it has been able to restrain the growth in demand even with a very rapid surge in population due to immigration from the former Soviet Union in the early 1990s. The immediate challenge that Israel faces is to further reduce the share of fresh water going to the agricultural sector. The historical mode, of administrative allocations, will not do the job, as it is subject to historical interests that will not readily accept the burden of such a change. One alternative is to extend the current initiative to divert fresh water from irrigation, and replace it with treated effluent. This option is limited by quantitative and qualitative constraints and can only serve as a partial solution. Fortunately, market mechanisms have been proposed, including tradable rights and the use of appropriate, scarcity pricing. If adopted, these changes will have a profound and beneficial impact on the whole water economy.

Adoption of similar policies by neighboring countries can provide temporary relief for the region as a whole. Two critical steps are required if the region is to avoid serious difficulties within this time span. One is that whatever the political circumstance, the means must be found to operate regionally (i.e., multinationally) to deal effectively with the externalities intrinsic to this scarce resource. The second is that efficiency in managing the stock of water requires much more effective use of the price mechanism. The advantage of the latter is that it tends to be less political and less bureaucratic, and hence can help avoid the problems that are bound to occur in any multinational efforts at regional cooperation. (Fisher, Eckstein).

Even with efficient pricing and regional cooperation in management, early in the next century, the growth in demand will once again bring serious water shortages to the fore. A number schemes to add to Israel's and the region's water supply are being vigorously promoted by their respective proponents: desalination; a variety of canal schemes; importing Turkish water, trapping of runoff via dams, etc. Despite substantial analysis of each proposal in isolation, we have been unable to discover a serious attempt to compare rigorously the full set of social costs and benefits from these alternatives, a discipline that is amenable to the tools of Social Cost Benefit Analysis. Indeed, water projects have been the first and still the most important field of successful application of this methodology. (El-Bihbety and Lithwick). The water authorities would be well advised to underwrite some base line studies in this area, to enable Israel to identify and implement realistic solutions.

Whichever scheme is adopted, progress towards regional cooperation in meeting short-term requirements can provide important institutional mechanisms for positive sum long-term solutions. Acting collectively as water buyers, import prices can be kept down. Acting collectively as project developers, economies of scale and positive externalities can be captured.

Paradoxically, Israel's recent successes in dealing with its short term challenges may lead it to resist those region-wide collaborative efforts that could do much to alleviate the longer term problems. Viewed constructively, a move towards regional cooperation may in the short run not only provide opportunities for low cost long term solutions, but could play a useful role in creating a less hostile geopolitical environment for all.

* *The author is Research Professor and Senior Fellow at the Negev Center for Regional Development, Ben-Gurion University of the Negev, Israel and former economics professor in the School of Public Administration, Carleton University.* *The research assistance is Ms. Tilly Shames, a visiting graduate student from the Norman Paterson School of International Affairs at Carleton University in Ottawa, Canada, and Mr. Dovi Wilensky, from the University of Santa Cruz, is gratefully acknowledged.*

ANNEX 1

Recent Water Balance Of The Sea Of Galilee
(MCM/YR)

Source of Flow	Inflow	Plus	Minus	Outflow
Flow into Sea of Galilee	544			
Rainfall over Sea		65		
Flow from Local Runoff		70		
Springs in and around Sea		65		
Evaporation from Sea Surface			-270	
Outflow to Lower Jordan R.				-474
Total Volume of Sea	4,000			

Source: Murakami, 1994, Table 3.

ANNEX 2

Stocks and Flows of Water from Major Sources
(MCM)

Source	Net Outflow	Overutilization	Accumulated Deficit
Underground			
1.Coastal Aquifer	240-455	34-80 (1980-90)	100-1400
2. Local Aquifers	23-280		Small
3. Mountain Aquifer	300-330	50 (1980-90)	300-350
Surface			
4. Sea of Galilee	575-950	25 (1980-85)	140
5. Floods and Treated Sewage	200-230		
TOTAL	1890-2311		1570
Water Losses	60-100		
BALANCE	1790		

Source: Kliot, Table 3.13

ANNEX 3

Comparison Of Alternative Water Import Schemes

Mode	Quantity (MCM/YR)	Price ($/CM)
Litani to Israel	100	0.14
Nile to Israel	500	0.20
Turkey Overland	1100	n/a
Turkey Medusa Bag	500	0.21

Source: Wolf, Table 4.3, p. 151

ANNOTATED BIBLIOGRAPHY

Allan, J. Anthony, 1998a, "Middle East water: local and global issues."
Website: http://endjinn.soas.ac.uk/Geography/Waterissues/Papers/9508ta_01.html
[Derides "hydroparanoia", arguing that despite excess presumed shortages of water, major adjustments have been made, in large part by importing "virtual water" in the form of agricultural produce (cereals) from countries that have a comparative advantage with respect to water.]

Allan, J. Anthony, 1998b, "Watersheds and Problemsheds: Explaining the Absence of Armed Conflict over Water in the Middle East", Middle East Review of International Affairs, 2,1, #5, March.

Allan, J.A., 1995, "Striking the "Right Price" for Water? Achieving Harmony between Basic Human Needs, Available Resources and Commercial Viability," in Allan, J.A. and Chibli Mallat, eds., Water in the Middle East: Legal, Political and Commercial Implications, I.B. Tauris Publishers, London, pp. 325-346.
[This book focuses on many legal issues but provides some insight into future potential, international agreements, and policy options].

Saul Arlosoroff, undated, "The Public Commission on the Water Sector Reform", International Water and Irrigation Review.

Awerbuch, Leon, 1988, "Desalination Technology: An Overview," in Starr, Joyce R. and Daniel C. Stoll, The Politics of Scarcity: Water in the Middle East, Center for Strategic and International Studies, Westview Special Studies on the Middle East, Ch. 4, pp. 53-64.

[Presents costs of various types of desalting plants].

Bar-El, Raphael, 1995, The Long Term Water Balance East and West of the Jordan River, Ministry of Economy and Planning, National and Economic Planning Authority, Kiryat Ben-Gurion, Jerusalem.
[This paper looks at water balances in Jordan, Israel and the West Bank and Gaza. The basis of the projections to the year 2040 are not provided, but they appear to be quantitative extrapolations without a clear economic rationale].

Beaumont, Peter, 1997, "Dividing the Waters of the River Jordan: An Analysis of the 1994 Israel-Jordan Peace Treaty", Water Resources Development, Vol. 13, No. 1, pp. 415-424.
[Argues that the treaty is particularly favorable for Israel, providing less water to Jordan than was proposed in the Johnson plan of the 1950s].

Bental, Benjamin, 1995, A Dynamic Macroeconomic Model of Water Uses in Israel, The Pinchas Sapir Center for Development, Tel Aviv University and The Armand Hammer Fund for Economic Cooperation in the Middle East (published in Hebrew as well in The Economic Quarterly, 43, 1, April 1996).
[Develops several scenarios about water allocation. One important finding is that while the cost of desalination is estimated to be about $0.80 per CM, the value of an extra 300 MCM of water to the economy is only $0.55. Nevertheless, despite increasing production costs of water, the economy is better off to face those higher costs and adjust water use accordingly, than shielding the economy from those costs and letting it act as if water is a free good. Even the higher cost of desalinated water is worth undergoing, because failure to develop such a source will have even greater, negative impacts on growth].

Braverman, A., N. Hasid, S. Drori, Y.Schwartz and Y. Maoz, 1994, The Water Economy in Israel, Working Paper for the World Bank (Hebrew).

Brooks, David, 1994, "Economics, ecology and equity: lessons from the energy crisis in managing water shared by Israelis and Palestinians", in Isaac, J. and H. Shuval, eds., Water and Peace in the Middle East, Elsevier Science, pp. 411-420.

Eckstein, Zvi, Dan Zakai, Yuval Nachtom and Gideon Fishelson, 1994, The Allocation of Water Resources between Israel, the West Bank and Gaza: An Economic Viewpoint, The Pinchas Sapir Center for Development, Tel Aviv University and The Armand Hammer Fund for Economic Cooperation in the Middle East.
[This is an excellent study of the core economic issues surrounding alternative methods of meeting water needs. It argues for rational pricing as the most efficient solution, one that is less costly than the alternatives being proposed such as desalination. The authors also argue that using the price mechanism is a more effective way to resolve disputes between Israel and the Palestinians over the distribution of water between them].

Eckstein, Zvi and Gideon Fishelson, 1994, The Water System in Israel, Paper prepared for the Harvard Middle East Water Project, April, mimeo.

El-Bihbety, Hisham, and Harvey Lithwick, 1998, "Cost-Benefit Analysis of Water Management Mega Projects in India and China," in H. J. Bruins and H. Lithwick, eds., The Arid Frontier, Kluwer.

Feitelson, E. and M. Haddad, 1994, eds., Joint Management of Shared Aquifers , Harry S Truman Research Institute, Hebrew University and the Palestinian Consultancy Group, Jerusalem.

Fishelson, Gideon, 1993, The Israeli Household Sector Demand for Water, Tel Aviv University and The Armand Hammer Fund for Economic Cooperation in the Middle East.
[Attempts to impose a price mechanism on the allocation of scarce water should be based on an appreciation of the characteristics of the demand for water by different categories of users in different countries. This study estimates the price and income elasticities of demand by the household sector in Israel].

Fisher, Franklin M., 1995 , "The Economics of Water Dispute Resolution, Project Evaluation and Management: An Application to the Middle East," Water Resources Development, Vol. 11, No. 4.
[Important article, demonstrating that by valuing water (including its social net benefits) it is possible to conceive of trading water rights for non-water benefits. Results for Israel demonstrate that the value of water in dispute is surprisingly low, increasing the prospects for peaceful resolution of such disputes].

Glueckstern, P., 1992, "Desalination – Present and Future", Water and Engineering, Vol 12, No. 2.

Government of Israel, Ministry of National Infrastructure, Water Commissioner, 1998, Water in Israel, Consumption and Production, 1996, Hebrew.
[This is a very comprehensive current and historical data and chart book of excellent quality. Only quantities are accounted for, however. That is, there are no data on cost and prices].

HARZA JRV Group, 1996, Jordan Rift Valley, Integrated Development Study: Red Sea – Dead Sea Canal Project, Draft Feasibility Study, Jordan Rift Valley Steering Committee of the Trilateral Economic Committee.
[Contains a Cost Benefit Analysis of this project that appears to overstate costs by including secondary benefits, generally not accepted in CBA. Without them, the economic rate of return would appear to be about 9%, rather low for a project of this sort].

Hillel, Daniel, 1994, Rivers of Eden: The Struggle for Water and the Quest for Peace in the Middle East, Oxford University Press.

Hochman, E. and O. Hochman, (1991) A Policy to Determine Efficient Prices of Water in Israel, The Center for Agricultural Economic Research, Rehovoth (Hebrew).

Issar, A.S., 1998, "Global Change and Water Resources in the Middle East: Past, Present and Future", unpublished m/s.

Issar, A.S., 1995, "Climatic Change and the History of the Middle East," American Scientist, 83, pp. 350-355.

Kally, Elisha, with Gideon Fishelson, 1993, Water and Peace, Praeger, Westport, CT.

Kliot, Nurit, 1994, Water Resources and Conflict in the Middle East, Routledge, London. *[Somewhat dated re data presented, but a very comprehensive introduction to the traditional analysis of water balances].*

Kolars, John, 1995, Integrating author, "Observations Regarding Water Sharing and Management: An Intensive Analysis of the Jordan River Basin with Reference to Long-distance Transfers,", based on the Middle East Water Commission Report, Water Resources Development, No. 11, No. 4, pp. 351-375.

Laronne, Jonathan, 1996, ed., Reservoirs as Sources of Water for the Negev, Report of a conference held on Feb. 15, 1996, sponsored by Ben-Gurion University, the Jewish National Fund, the Ministry of Agriculture, and Mekorot.

Lindholm, Helena, 1995, "Water and the Arab-Israeli Conflict," in Leif Ohlsson, ed. Hydropolitics: Conflicts over Water as a Development Constraint , Zed Books, London.

Lonergan, S.C. and David Brooks, 1995, Watershed: The Role of Fresh Water in the Israeli-Palestinian Conflict, IDRC, Ottawa, Canada.

Lowi, Miriam R., 1993, Water and Power: The Politics of a Scarce Resource in the Jordan River Basin, Cambridge University Press.
[Reviews the role of water in conflict and negotiations].

MEWIN (Middle East Water Information Network), 1998, "Israeli Water Use and Exports'", download from Internet site, http://gurukul.ucc.american.edu/ted/ Sept.13.

Murakami, Masahiro, 1995, Managing Water for Peace in the Middle East, Alternative Strategies, Tokyo, NY, Paris, United Nations University Press.

Murakami, Masahiro and Katsumi Musiake, 1994, "The Jordan River and the Litani," in Asit K. Biswas, ed., International Waters of the Middle East: From Euphrates to Tigris to Nile, UNEP, Ch. 5, pp. 117-155.

Nachmani, Amikam, 1995, "Water Jitters in the Middle East", Studies in Conflict and Terrorism, Vol. 17, No. 1, Rand, California.

Regev, Uri, A. Schwartz and A. Cohen, 1975, "The Development of Water Resources in Israel", in Y. Mundlak, ed., Studies in Agricultural Economics, Center for Agricultural Economic Research, Faculty of Agriculture, Hebrew University, Rehovoth (Hebrew).

Shuval, Hillel, ed., 1980, Water Quality Management under Conditions of Scarcity: Israel as a Case Study, Academic Press, New York.
[This is an older reference with a very broad scope].

Starr, Joyce R., and Daniel C. Stoll, eds., 1988, The Politics of Scarcity: Water in the Middle East, Center for Strategic and International Studies, Westview Special Studies on the Middle East, London.
[An older reference, it looks at technological options in particular with some costing especially of desalination].

Center for Engineering and Planning, 1994, Water Conservation in Palestine: An Integrated Approach Towards Palestinian Water Resources Management.
[Provides a different, Palestinian perspective].

TAHAL, 1988, A Master Plan for the Israeli Water Market, (Hebrew).
[This report presents estimates of supply and demand for 1984/85 and for 2010 by district. It forms the basis of most studies until very recently].

Wachtel, Boaz, undated, The Peace Canal Plan, mimeo.

Wolf, Aaron T., 1995, Hydropolitics Along the Jordan River: Scarce Water and its Impact on the Arab-Israeli Conflict, Tokyo, NY, Paris, United Nations University Press.
[Contains useful material on the history of water conflicts].

World Bank, 1993, Water Resources Management, World Bank Policy Paper.
[Makes a persuasive case for a coherent, comprehensive approach to water management with particular emphasis on the use of relevant prices, decentralization of authority, attention to environmental consequences, and rigorous assessment of investment projects].

Yunger, Miri, Naomi Carmon, and Uri Shamir, 1993, Who Benefits from Israel's Water Resources? A Comparative Study of Kibbutzim and Moshavim, The Center for Urban and Regional Studies, The Technion – Israel Institute of Technology (Hebrew).

Zaslavsky, Dan, 1997, Solar Energy Without a Collector for Electricity and Water in the 21st Century, Lecture to the Austrian Academy of Sciences, May, Mimeo.

ACKNOWLEDGEMENTS

This paper was made possible by the assistance of a number of individuals and groups who kindly provided me with information, references, advice and cautions. The principal author alone is responsible for their use. Among those who helped, we would like to specifically thank the following:

Prof. Tony Allen, SOAS, University of London
Prof. Shaul Arlosoroff and Prof. Hillel Shuval, Hebrew University, Jerusalem
Prof. Raphael Bar-El, Faculty of Management, Ben-Gurion University
Prof. Zvi Eckstein, Tel Aviv University
Prof. Franklin M. Fisher, M.I.T.
Dr. Nava Haruvy, Agricultural Research Association, The Volcani Center, Bet Dagan, Israel
The Israel Information Center
Dr. Moshe Israeli, Israel Water Commissioner
Mrs. Esti Landau, The Armand Hammer Fund for Economic Cooperation in the Middle East, Tel Aviv University
Malaika Martin and Prof. Barry Rubin, MERIA, Begin-Sadat (BESA) Center
Prof. Thomas Naff, University of Pennsylvania MEWIN
Prof. Uri Regev and Prof. Moshe Justman, Department of Economics, Ben-Gurion University of the Negev, Beer Sheva
Prof. Uri Shamir, Prof. Josef Hagin, and Ms. Ella Offenberger, Water Research Institute, University of Haifa.
Boaz Wachtel, Consultant, Tel Aviv
Prof. Amos Zemel, Prof. A. Issar, Prof. Gideon Oron, and Dr. Hendrik Bruins, The Desert Research Institute, Sde Boqer

תקציר

ישראל מהווה מקרה מבחן מעניין של הדרך בה מתפתחת ההבנה של מאזן המים הלאומי בעקבות שכלולים טכנולוגיים, תחכום כלכלי גובר ופוליטיקה פנימית ואזורית.

במשך העשור החולף במיוחד, המחקר בישראל גילה כי בעיות מים ניתנות לפתרון על ידי ניצול כוחות השוק. כתוצאה מכך, מה שנתפס בעבר כמשבר מתהווה, נראה כעת - באופן מציאותי יותר - כבעיה של הקצאה, בעיה שאינה פשוטה אך יחד עם זאת הינה הרבה פחות אפוקליפטית.

יתרה מזו, טמון בכך הפוטנציאל לטיפול משופר בסוגים שונים של סכסוכים אזוריים, על ידי יישום אסטרטגי של משטרי תמחור וניהול. כתוצאה מחשיבה-מחדש מעין זו, חל שינוי רדיקלי במדיניות המים הישראלית-פנימית במהלך העשור, ויש לקוות כי אותו סוג של חשיבה יסייע לפתרונן של מחלוקות ישנות ברמה האזורית-בינלאומית.

מרכז הנגב לפיתוח אזורי

נייר עבודה מס' 10

הערכת מאזן המים בישראל

מאת

הרווי ליטוויק
מרכז הנגב לפיתוח אזורי

בשיתוף
טילי שיימס ודובי וילנסקי

דצמבר 1998

מרכז הנגב לפיתוח אזורי

מרכז הנגב לפיתוח אזורי הוקם באוניברסיטת בן-גוריון בנגב בשנת 1993. המטרה העיקרית של המרכז היא לבצע מחקרי מדיניות יישומיים, ולספק מידע עדכני ומקצועי על הנגב למתכננים, פוליטיקאים, אנשי-עסקים, חוקרים והציבור הרחב. המרכז משתמש במקורות המידע המהימנים ביותר ובשיטות המחקר והתכנון הטובות והמתקדמות ביותר, כדי לענות על הצרכים המגוונים של הנגב בפרט ושל מחקר הפיתוח האזורי בכלל.

סידרת ניירות-העבודה של המרכז

מרכז הנגב לפיתוח אזורי מוציא לאור סידרה של ניירות-עבודה, כאמצעי להביא לידיעת הציבור את הממצאים האחרונים ממחקרים תיאורטיים ויישומיים המתבצעים במרכז או ממומנים על-ידיו. הסידרה תהווה גם אמצעי לפרסם מימצאי מחקר עדכניים על נושאים כלליים בפיתוח עירוני ואזורי, במיוחד בישראל.

הסידרה, בעריכת ד״ר אורן יפתחאל, תקבל עבודות בעברית, אנגלית, וערבית. ניירות-העבודה יופצו בין הרשויות והמוסדות הרלוונטיים בישראל ובחוץ-לארץ, וכן בין כל הגורמים המעוניינים האחרים.

כתובת להזמנות או למסירת עבודות:

ד״ר אורן יפתחאל

מרכז הנגב לפיתוח אזורי

אוניברסיטת בן-גוריון בנגב

ת.ד. 653, באר שבע 84105

פקס:972-7-6278991

e-mail: yiftach@bgumail.bgu.ac.il

מרכז הנגב לפיתוח אזורי אוניברסיטת בן-גוריון בנגב
NEGEV CENTER FOR REGIONAL DEVELOPMENT BEN-GURION UNIVERSITY OF THE NEGEV

נייר עבודה מס׳ 10

הערכת מאזן המים בישראל

הרווי ליטוויק
מרכז הנגב לפיתוח אזורי

בשיתוף
טילי שיימס ודובי וילנסקי

דצמבר 1998

ISSN 0793-6780