Water Scarcity in the Middle East? Misallocation or Real Shortages

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1.0 INTRODUCTION

Water as a source of conflict among neighbours is not a rare phenomenon in history, either in the Middle East or in other regions. Conflict is generally rooted in scarcity. Water in the Middle East is very scarce and has become acutely so in the last decade on account of poor rain fall and an incessant increase in the demand for water. This scarcity is expected to become even more acute with the arrival into Israel of several thousands of Jewish immigrants from East Europe and the ex-Soviet Union. It is not surprising, therefore, to find water at the root of much of the conflicts in the region. Data on water availability and usage in the region is, however, as scarce and limited as water itself, but particularly when it comes to water allocation among different uses and users. This is a significant drawback as the real issue of scarcity of water in the region is also strongly tied to improper allocation mechanisms and inappropriate pricing practices. Fortunately, the limited availability of data on water is not true for all countries of the region. There appears to be sufficient data for Israel, Egypt and Jordan that can be used to gauge the question of absolute (relating to total water availability) versus relative (relating to sectoral allocations) water scarcity.

The main contention of this paper is that a more economic use of this resource based on appropriate pricing and allocations can go a long way into relieving current and future water shortages and therefore conflicts.

Current water policies in the region have engendered a culture of waste. Water is priced far below its marginal cost of production, leading to over-irrigation and the expansion of production of water-intensive products in a region characteristically short on water. Estimates of the marginal product of water in agriculture in Israel are several multiples of the water rates charged (Sadan and Ben-Zvi, 1987). In fact, water rates plus fines imposed on over use are still significantly below estimated marginal product values (Kubursi, 1981).

Economic efficiency calls for distributing scarce resources to their best uses. Prices below marginal cost of production invites reckless waste and indeed evidence on water use rates in the region is consistent with this prognosis. Water use in agriculture in Israel is at least 67% of total available water (Fishelson, 1991). Equally disturbing is the fact that most of the products of the Israeli agricultural sector are water intensive and the trend is for greater rather than lower water intensity (Fishelson, 1991). While good data does not exist for other countries in the region, it is not difficult to believe that perhaps a similar situation of water waste is true in the region at large. Besides reckless use and waste on the demand side of the equation, the system has encouraged excessive investments in increasing the water supply in agriculture even though the resources allocated to this effort could contribute more if used in other activities and sectors.

Optimal uses of resources may be attained by insuring that marginal costs of production are proportional to prices. While marginal costs can be easily determined, finding the appropriate price presents a challenge. Market prices are often distorted by administrative interventions, subsidies or taxes. In these circumstances it is critical that the true scarcity price be used. This is equivalent to what economists refer to as the shadow price. This can be calculated using simple linear programming techniques as will be shown below. The water constraint can be specified as a fixed total availability which assumes, not unreasonably, perfect substitution among uses and users. Alternatively, it can be specified in terms of sectoral constraints assuming zero substitutability among sectors.

The implicit contention of this paper is that water uses in the region are sub-optimal and that by shifting the uses among sectors and activities we may be able to improve efficiencies of use and reduce the severity of the water constraint and therefore total water scarcity and the connected insecurities associated with this perceived scarcity problem.

2.0 Absolute Scarcity

Israeli water balances and practices will be singled out to test our model and to evaluate our basic contentions. Several reasons account for this. First, Israel's under pricing of water is now well documented and constitutes a solid background for establishing a base of comparison with optimal uses and shadow prices. Second, Israel has laid heavy emphasis on agriculture which appears to draw away resources from more efficient users and uses.

Third, Israel has a comparatively solid database on water uses by region and sector that does not exist in any other country in the region. Fourth, there exists a rich literature on Israel's water problems and practices that constitutes a useful background for comparing our results.

This does not mean that other countries' problems and conditions will not be discussed. Whenever appropriate and when comparable data exists, we will draw on other countries' experiences.

To assess the overall scarcity of water under the assumption of a global water constraint independent of use or user we begin with a general model that maximizes GDP at factor cost subject to total available resources.

The important components of the model include an objective function

Maximize GDP (1)

subject to a detailed set of constraints and definitional equations. First, the commodity balances of the Israeli input output of 1975/76 are incorporated, with private and public consumption treated as endogenous to the system.

$$\sum_{j=1}^{40} a_{ij}x_j + b_i C + g_i GC + F_i \le x_i \qquad (2)$$

The 40 inequalities in (2) state that intermediate and final demand for domestic production of commodity 1 should not exceed the available domestic supply.

Government revenues minus subsidies plus transfers and borrowing from home and abroad are constrained to exceed government expenditures on current and capital account. Thus, the government budget constraint is described as

$$\sum_{i=1}^{40} t_i x_i + b_t C + t_v VA + (g_t - 1) GC \geq F_g - FT + GI + E_t \qquad (3)$$

Labour is assumed to be mobile across sectors and an aggregate labour constraint is specified

$$\sum_{i=1}^{40} 1_i x_i + 1_c C + 1_g GC \leq L \qquad (4)$$

An oil import constraint is imposed on the model taking the form

$$m_{fo} X_o \leq O \qquad (5)$$

The balance of payments constraint is specified to restrict imports to the total foreign exchange proceeds from exports and foreign capital imports

$$\sum_{i=1}^{40} m_i X_i + b_m C + g_m GC + I_m + V_m \leq \sum_{i=1}^{40} E_i + E_t + FT + RP \qquad (6)$$

Forty additional constraints are imposed on the model which allow output to exceed actual volumes in 1975/76 by 15%. This form is adopted to compensate for the limited knowledge of the capital-output coefficients and capital capacities for some of the sectors

$$X_i \leq 1.15\ X_i \qquad (7)$$

Consumption is specified to respond to value added net of taxes and private transfers net of taxes

$$C = c(1-t_y)GDP + (1-t_y)RP + C \qquad (8)$$

Finally, GDP is defined to include

$$GDP = \sum_{i=1}^{40} v_i X_i + b_v C + g_v GC \qquad (9)$$

The general tableau of the system is presented below.

List of Variables

X_i = the total amount of domestic production of commodity I in IL million, where X_o is the output of the oil sector.

$\overline{GI}$ = total government investment in 1975 in IL million

C = total private consumption in IL million

VA = value added in IL million

GC = government consumption in IL million

a_{ij} = the amount of domestically produced resource i used in the production of one unit of output j

v_i = value added per unit of output of sector i

b_i = the fraction of total private consumption supplied by commodity i

g_i = the fraction of government consumption supplied by commodity i

m_i = the amount of imports per unit of output i

t_i = the total amount of taxes net of subsidies per unit of output i

l_i = total man-years of labour per unit of output i

l_c = total man-years of labour per unit of private consumption

l_g = total man-years of labour per unit of government consumption

c = the marginal propensity to consume

t_v = taxes per unit of value added

b_t = taxes net of subsidies per unit of private consumption

g_t = taxes collected on public consumption

b_m = imports of final consumer goods per unit of private consumption

g_m = imports of final consumer goods per unit of government consumption

m_{fo} = imports of crude petroleum per unit of output of the refining sector $= m_{19}$

g_v = value added by unit of government consumption

b_v = value added by unit of private consumption

I_i = investment expenditures on commodity i in IL million

$\overline{V}_i$ = change in inventories of commodity i in IL million

$\overline{E}_i$ = exports of commodity i in IL million

$\overline{E}_t$ = export subsidies in IL million

$\overline{FT}$ = public foreign capital imports in IL million

$\overline{RP}$ = private transfer payments from abroad in IL million

$\overline{L}$ = the number of persons in the labour force

$\overline{O}$ = the total import bill of oil in IL million

$\overline{X}_i$ = the actual value of the output of sector i in the 1975 input-output in IL million

$\overline{C}$ = the reconciliation item between the consumption function and actual consumption in 1975 in IL million

$\overline{F}_i$ = investment, change in inventories and exports of sector i in 1975 in IL million

$\overline{F}_g$ = government revenues associated with investment, change in inventories and exports in 1975 in IL million

$\overline{I}_m$ = imports associated with investment in 1975 in IL million

$\overline{V}_m$ = imports associated with change in inventories in 1975 in IL million

The Tableau of the Planning Model

	X_1	X_{40}	C	VA	GC		Exogenous variables
	$a_{1,1}$	$a_{1,40}$	b_1	0	g_1	$<$	$-\bar{F}_1$
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	.	.	.	.	.	.	.
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	.	.	.	.	.	.	.
	$a_{40,1}$	$a_{40,40}$	b_{40}	0	g_{40}	$<$	$-\bar{F}_{40}$
	m_1	m_{40}	b_m	0	g_m	$<$	$-\bar{I}_m - \bar{V}_m + \sum_{i=1}^{40} \bar{E}_i + \bar{E}_t$
							$+ \overline{FT} + \overline{RP}$
	t_1	t_{40}	b_t	t_v	g_{t-1}	$>$	$-\overline{FG} - \overline{FT} + \overline{GI} + \bar{E}_t - tv\,\overline{RP}$
	l_1	l_{40}	l_c	0	l_g	$<$	$\bar{L}$
	1	0	0	0	0	$<$	$1.15\bar{X}_1$
	.	.	.	.	.		.
	.	.	.	.	.		.
	.	.	.	.	.		.
	0	1	0	0	0	$<$	$1.15\bar{X}_{40}$
	0 ... m_{19} ...	0	0	0	0	$<$	$\bar{0}$
	v_1	v_{40}	b_v	-1	g_v *	=	0
	0	0	1	$-c_{(1-t_v)}$	0	=	$c_{(1-t_v)}\,\overline{RP} + \bar{C}$
MAX	0	0	0	1	0	objective function	

The extent of sensitivity of the economy to reduced water availability are depicted in Table 1 below. The results in Table 1 indicate rather strikingly that if water alone were to be reduced the Israeli economy would experience drastic cuts in maximum GDP and a rapid rise in the shadow price of water. When water availability is reduced by 20% GDP in 1968 prices drops by 9%. The shadow price of water rises from IL 0.44 to IL 142.74. Further drops in water availability result in steeper rises in shadow prices and steeper declines in GDP. Reductions exceeding 30% of water availability, other things being equal, result in infeasibility of the system, i.e., no solution can satisfy the constraints of the model.

Table 1. The Economic Impact of Reducing Water Availability in Israel

Water Availability (IL Million)	Optimal GDP (IL Million)	Shadow Price (IL)
1088	74813	0.44
975	74592	4.95
875	72691	142.74
800	60191	186.32
750	not feasible	

Source: Linear Programming Solution

3.0 Relative Water Scarcity

The results above are generated under the assumption that water is not necessarily constrained in any sector. Only one single global constraint was imposed on the economy.

The "Water Law" (Israel Ministry of Agriculture, 1968) defines the legal foundation for state intervention in the allocation of water. Water resources, under the law, are owned by the state which carries the sole responsibility to allocate it among users and uses. The law stipulates that water prices be equalized across regions and users despite differential costs of production and distribution. In effect the Law resulted in uniform prices that are effectively nominal. The effective state instrument of allocation was nontransferable quotas rather than water charges (Sadan and Ben-Zvi, 1987, p.3). These nontransferable quotas resulted in some severe inefficiencies and misallocations over space.

3.1 Regional Rigidities

Using a similar optimization model of the one described above, Sadan and Ben-Zvi add a new set of constraints which includes:

1) The agricultural system (input output coefficients) is exogenous to the system.

2) The system of water conveyance at the national and regional level is exogenous to the model. Upper limits on "average" and peak -month conveyance are given.

3) The institutional system determining the water allocation is represented in the model at the 1980 position and can be tested by parametric iterations.

4) Competition exists among production entities (kibbutz or moshav or private farm villages in the various regions) for their part in the domestic markets for farm products.

5) Prices of tradeable farm products are given. For nontradeable farm products the demand

quantities at the going prices are given.

The model was used to examine the impact of institutional changes on economic efficiency. In other words the model was used to estimate the real (shadow) price of water locally and regionally when the system is assumed to be free from all barriers on transfers of quota privileges. What is striking in their results is the magnitude of change in the regional pattern of water allocation.

Table 2 summarizes these results which include:

a) The Upper Basin of the Jordan is found to overuse irrigation water. If water charges were increased to reflect the true scarcity of this water a surplus of water would emerge that could be transported through the national water carrier to other regions.

b) A decrease in water supply would emerge in the South. The Centre (Coastal Plain and Northern Valleys) would benefit. The net effects of uniform and nominal prices are overutilization of irrigation water in the North, an oversupply in the South and excess demand in the Centre.

Once the model allows for the free transfer of water to areas with lower opportunity cost a new allocation of water results. Over and under utilization of irrigation water is reflected by wide disparities of shadow prices. (See Table 3).

Table 2. Interregional Reallocations of Irrigation Water, Israel Late 1970s.

Region	Actual Allocation (%)	Optimal Allocation (%)	Difference (%)
Jordan River Basin	26	22	-4
Galilee	5	4	-1
Northern Valleys	13	15	+2
Coastal Plain	36	48	+12
South	20	11	-9
Total	100	100	0

Source: Sadan and Ben-Zvi, 1980.

Table 3. Water Charges and the Value of Marginal Product of Irrigation Water

Sub Region	Nominal Water Charges Paid by Farmers*	Shadow Price Under Actual Conditions	Shadow Prices Under Optimal Conditions
		Upper Basin Jordan River	
Hula	4.00	9.75	12.25
Bet She'an	1.00	6.00	8.50
		Northern Valleys	
Akka	3.50	17.75	16.50
Yizre'al Basin	5.25	28.00	18.25
		Coastal Plain	
Hadera	3.75	17.25	15.00
Sharon	3.25	16.75	15.00
		South	
	5.75	14.75	21.00

Source: Sadan and Ben-Zvi, 1980.

* Charged by Mekorot Ltd., operating Israel's national water supply system.

3.2 Sectoral Rigidities

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PROGRAM

FOR

THE MIDDLE EAST WATER CRISIS: CREATIVE PERSPECTIVES AND SOLUTIONS

Day 1: May 8, University of St. Jerome's College

[all participants with an asterisk (*) are confirmed]

9:00 Opening Address

Chair: Terrence Downey *(University of Waterloo)*

<u>*Address from the Government of Canada*</u>

***The Honourable Monique Landry** *(Minister for External Relations and International Development)*

9:45 Session 1: Defining the Perimeters and Parameters of the Issues and Problems

Chair: *Steve Lonergan *(Chair, Panel on Environmental Security: Canadian Global Change Program)*
(Director, Centre for Sustainable Regional Development: University of Victoria)

*John Kolars *(University of Michigan)*
*Hussein Amery *(McMaster University)*
*Fred Frey *(Pennsylvania State University)*
*Elias Salameh *(Director, Water Research and Study Centre: University of Jordan)*

Discussant: *David Brooks *(Associate Director, Environment Policy Program: International Development Research Centre)*
* Jouad Boulos *(Lawyer, International Water Law)*

12:30 Luncheon

2:00 Session 2: Past Issues and Attempted Solutions.

Chair: *Bruce Mitchell *(University of Waterloo)*

*Aaron Wolf *(University of Wisconsin)*
*Jad Isaac *(Director, Applied Research Institute – Jerusalem)*
*Atif Kubursi *(McMaster University)*

Discussant: *Ibrahim Mattar *(American Near East Refugee Aid Program – Jerusalem)*
*Miriam Lowi *(Princeton University)*

7:30 Banquet Dinner

Chair: Marie Sanderson *(Director, Water Network: University of Waterloo)*

*Dr. Robert Farvolden *(Ground Water Institute, University of Waterloo)*
(Former Dean of Science Faculty, University of Waterloo)

Day 2: **May 9, University of St. Jerome's College (morning) and Theatre of the Arts in the Modern Languages Building (afternoon)**

9:00 **Session 3: Political, Technological, and Economic Solutions to Current and Projected Problems**

Chair: *John Keenan *(Professor of Civil Engineering Systems and Associate Dean, School of Engineering and Applied Sciences: University of Pennsylvania)*

*Ulrich Kuffner *(Principal Water Resources Engineer, World Bank)*
*Aly Shady *(Chief of Irrigation Centre, Natural Resources Division: Canadian International Development Agency)*
*Dan Hillel *(Professor of Plant and Soil Sciences: University of Massachusetts)*

Discussant: *John Waterbury *(Professor of Politics and International Affairs, Princeton University)*
*Ribhi Abulhaj *(Former Director, United Nations Inustrial Development Organization Office, West Asia)*

12:30 **Lunch**

2:00 Session 4: **Forum on the Implementation of the Proposed Solutions and Water Conflict Resolution Mechanisms.**

Chair: *Janice Gross Stein *(University of Toronto)*

*Munther Haddadin *(Chief Water Negotiator, Jordanian Delegation: Middle East Peace Talks)*
*Jad Isaac *(Director, Applied Research Institute – Jerusalem)*
*Ilter Turan *(Chair, Department of International Relations: University of Istanbul)*
*Jerry Delli Priscoli *(Water Policy Group, World Bank)*

Discussant: *Selig A. Taubenblatt *(Executive Consultant, Bechtel Group, Inc: Washington, D.C.)*

4:30 *Concluding Speech*

**Chair:* John English *(President, Canadian Institute of International Affairs)*

His Excellency Samir Kawar *(Minister of Water and Irrigation, Hashemite Kingdom of Jordan)

5:00 *Conference Summary*

Rapporteur:

*Steve Lonergan *(Chair, Panel on Environmental Security: Canadian Global Change Program)*
(Director, Centre for Sustainable Regional Development: University of Victoria)

5:30 ***press briefing***

Contributors to the Conference

Centre on Foreign Policy and Federalism Organizing Committee:

Mr. Paul Mitchell, Conference Organizer
Dr. John English, Director, Centre on Foreign Policy
Dr. Terrence Downey, Conference Coordinator
Dr. Bruce Mitchell, Conference Coordinator

Special Contributors:

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