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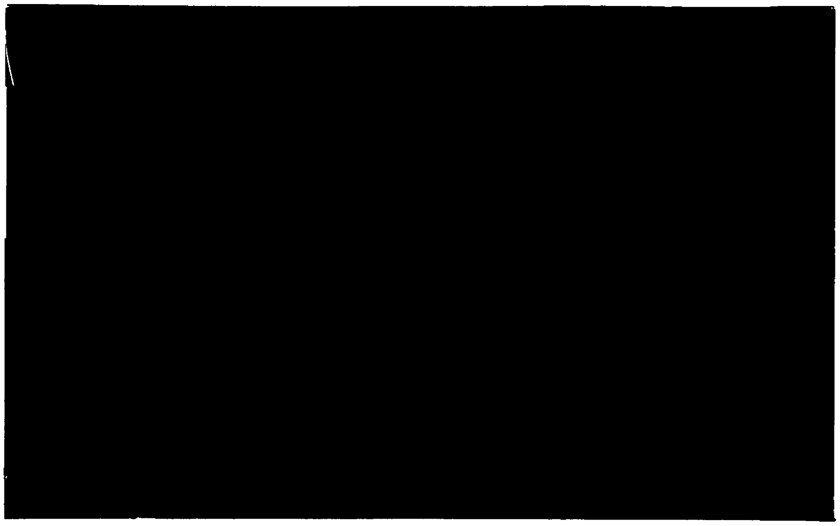

Problems and Prospects in the Political Economy of Trans-Boundary Water Issues

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ABSTRACT

The problem of water scarcity has become more acute in many regions of the world because of economic and population growth and because of degradation of historic water resources. New resources and more efficient use of old ones are needed, but large investments and effective institutions are needed for allocating water, monitoring its use, and ensuring its quality. Because most economically feasible but yet undeveloped water projects involve water drawn from and used by multiple jurisdictions, regional or international cooperation is required. This paper develops and applies a framework to evaluate the potential for trans-boundary cooperation in water resource development/sharing with an application to Israel and its neighbors.

The paper first gives an overview of water issues in Israel and the Jordan River basin. The Middle East is a water stressed region. Prior agreements on international use of water have been partially adopted but are highly disputed because of changing conditions including international borders. Water use is characterized by subsidized prices in agriculture, increasing block rate pricing in both agricultural and domestic uses, and spatial differences in water pricing due to the increasing block rate structure and the quotas on which it is based. These considerations suggest that current water allocation is inefficient. Unequal water prices and, particularly, low water prices in agriculture are typically attributed to political power. Water markets are widely propounded as a means of efficient water allocation by comparison. However, water markets may not take into account market failures and non-market considerations. If such concerns are legitimate, then valuation of new projects and the additional water availability they create must take these concerns as well as typical political-economic power factors into account.

Valuation of potential international water projects and design of successful sharing arrangements must consider the marginal value of water to participating countries. However, with unequal prices among users, the marginal valuation of water for individual countries depends on which users get the water. To take into account the extent to which existing pricing structures have been put in place to correct market failures and take into account non-market concerns, a model is developed where parameters represent inter-sectoral pricing relationships imposed thereby.

This paper focuses on two international water projects. The first requires bilateral cooperation between Israel and Jordan on the construction of two canals. The first would carry currently unused winter flood waters from the Yarmouk River to Lake Kinneret in Israel for storage. The second would carry stored water back to the riverbed for use in irrigation along the Ghor Canal in Jordan in the summer. Less water would be returned than pumped to the Kinneret so that Israel would also benefit from increased water supply.

The second project is a dam between Syria and Jordan on the upper Yarmouk River. This dam would also store winter flood waters for later use by Jordan in irrigation while Syria would benefit from electricity generation. Construction of the dam is currently blocked because the World Bank will not release a pending loan until Israel removes its objection. Thus, this project requires multilateral cooperation. The Kinneret canal project can provide lower-cost water but requires more sensitive cooperation than the dam project.

This paper also considers water cooperation between Israel and the Palestinians with respect to water use in Judea and Samaria. The problem here is that Israel uses water emerging in springs fed by the Mountain Aquifer in Judea and Samaria. Because the Palestinians are high-elevation users, their costs are greater and are increased by Israel's use. Also, because of a common property problem, overpumping of the aquifer is a potential problem.

Market solutions to international water allocation problems may not be currently feasible because of lacking infrastructure, monitoring capabilities, and trading relationships. More importantly, market solutions may be unacceptable politically for international water projects for two reasons. First, the marginal value of water tends to be quite different among countries. Thus, an increment of water availability tends to be allocated entirely to the country with highest marginal value of water. Second, many efficient but as yet undeveloped water projects, because of terrain and geographical considerations affecting water transportation costs, are such that the most economical users are located in a nearby region across an international border. Because of political concerns and uncertainty in demand growth, countries are understandably reluctant to enter into agreements that allocate all of the increment in a constraining resource to another country even if compensated monetarily.

Bargaining theory explores opportunities that provide incentives for cooperation to all participating parties. In some cases, bargaining solutions are remarkably robust but can be quite different than market solutions. Application of bargaining theory demonstrates how incentives for cooperation can change drastically when other new investments are undertaken and how the difference in ex ante and ex post incentives may cause agreements to break down once investments are made.

This paper also discusses the possibilities for improving domestic water allocation both among regions and sectors. The benefits from partial domestic price equalization are apparently greater than the benefits of international cooperation but are blocked by other national objectives. However, international water projects may be instrumental in facilitating domestic price equalization because the costs of price equalization to losers are reduced when the two measures are undertaken in conjunction. Conversely, when prices are partially equalized as international projects are undertaken, the value of international projects is higher. With these considerations, new water projects and new prospects for peace in the region can potentially break existing coalitions behind current water pricing schemes.

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1. Introduction

The problem of water scarcity has become more acute in many regions of the world because of economic and population growth and because of degradation of historic water resources. New sources and more efficient use of old ones are needed but large investments are required and effective institutions are needed for allocating water, monitoring its use, and ensuring its quality. Because most water projects involve water drawn from and used by multiple jurisdictions, regional or international cooperation is required. Improvement in demand and supply management holds potential for increasing water availability domestically but political realities do not always permit economic optimization.

In many countries, socio-political issues such as food security, tradition, settlement policy, development of arid regions, and equity dominate the cost of water supply among national priorities. Economic improvements must be considered in the context of socio-political goals. Identifying economic measures that are feasible in the context of national objectives can reduce the cost of maintaining idealogies but can also reduce the need to pursue some non-economic goals. For example, international cooperation made possible by peace can make water supply enhancing projects feasible while the feedback effects of improved international trust can reduce the need for security which may motivate some water pricing inefficiency.

This paper considers the potential for trans-boundary cooperation in water resource sharing with an application to Israel and its neighbors. Past conflicts and cooperation over water resources in the Jordan Basin and the Mountain Aquifer are discussed along with the potential for new international projects. Domestic water issues in Israel, Jordan, and Judea and Samaria are also considered as a standard of comparison. The economic potential for new international projects is discussed in the context of existing domestic water pricing inefficiencies imposed by socio-political factors. The benefits of these projects are compared to the benefits of domestic measures that improve economic efficiency. The ongoing peace process is considered as a catalyst that can enable a combination of these measures given the associated feedback effects.

The discussion of international projects considers the strategic possibilities that complicate international agreements. This necessitates viewing international cooperation as a two stage process where in the first stage governments negotiate a sharing arrangement and, possibly with World Bank help, design and pay for large scale projects such as reservoirs and dams. In the second stage, the question of compliance with the sharing arrangement must be addressed given strategic behavior that becomes possible once investments are in place. Because these decisions are separated over time, water allocation rules must be robust to changes in governments, economic variables, political forces, and water availability.

2. Overview of Trans-Boundary Water Issues in Israel and the Jordan River Basin

Increasing Scarcity and Alternative Options. Water scarcity is a major problem in the Jordan River Basin. Per capita water availability is far below the "water stress zone" in Israel, Judea, Samaria, the Gaza Strip, and Jordan (Falkenmark, Lunkqvist, and Widstrand 1990). This scarcity has led to major disputes over water use. In Israel, Jewish and Arab populations face severe conflicts over the exploitation of the Mountain aquifer water in Judea and Samaria. High population growth and lack of water resource planning have created severe water scarcity in Gaza as well. At the international level, Israel, Jordan, Syria, and Lebanon have severe and long-standing disputes over water allocation in the Jordan Basin.

For the most part to date, countries have attempted to solve scarcity problems by domestic means. Options on the supply side include reuse of sewage effluent, use of marginal floodwater and saline sources, seawater desalination, cloud seeding, internal transfer of water surplus, and separation of drinking water from irrigation and industrial water permitting use of recycled waste water in the latter uses (Rhoades and Dinar 1991). All of these options are either expensive or have an uncertain payoff. Many of these options are currently being pursued on an experimental basis but potential is limited unless new technology can be developed that lowers cost and/or produces more certain benefits. On the demand side, domestic water conserving measures include reducing agricultural production, changing agricultural cropping choices, and employing a price mechanism to reduce marginal price inequities among sectors and regions after accounting for public water cost differences. These options have more certain economic benefits but are possibly contrary to other national objectives.

With little doubt, water is not allocated efficiently within any of the Middle East countries. Simple economic efficiency analysis suggests that domestic reallocation of water could well postpone water scarcity problems. For example, the agricultural sector is the main water user and pays a water price below other sectors. This pricing structure induces farmers to use water to the point where its marginal value is below marginal values of water in other sectors. A reallocation of water away from agriculture holds potential for raising the aggregate benefits of water use and making available the water needed for further industrial and urban growth. Certainly, the increase in water scarcity and decline in water quality that has resulted from increased industrial and urban demands raises questions regarding social efficiency of the agricultural sector under its present structure (Dinar and Zilberman 1991; Kanazawa 1991). The lack of efficient management has been underscored recently by consecutive years of drought.

Reduced water allocation to agriculture will induce costly structural changes including (1) adoption of more efficient, capital-intensive irrigation practices (Tuijl 1993), (2) a shift to crops that require less irrigation and inferior water quality, and (3) elimination of low-value crops (e.g., field crops) and/or water-intensive crops (e.g., cotton) that likely do not pay the full cost of water. Further urban and industrial growth and/or reductions in agricultural water use will likely result in declines in overall cultivation and a relative shift in cropping toward fresh flowers, fruits, and vegetables that earn a high return in European markets sufficient to cover the full cost of water. Such restructuring, however, would necessitate abandoning food self-sufficiency policies such as pursued by the Israeli Ministry of Agriculture.

While obvious possibilities exist for cutting water use by restructuring agricultural cropping patterns or reducing total agricultural activity, these options may not be consistent with other national objectives. Economic aspects of water are not necessarily a top priority for many nations. For example, government policies may give higher priority to ideological and national security considerations. Subsidized agricultural water prices may simply reflect a comparative advantage in pursuing legitimate socio-political goals such as settlement of remote areas for security purposes. Thus, the potential gains revealed by simple economic efficiency analysis may not be practical in the larger scheme of things.

A brief assessment of domestic options suggests that, unless new domestic supply-enhancing technologies surface or national objectives change substantially, water shortages are likely to become acute and force major restructuring of domestic water use. Even if feasible domestic conservation possibilities are pursued, increases in the demand for water due to population growth and rising living standards are likely to cause water self-sufficiency to be lost in the foreseeable future. Alternatively, effective water supply can be increased by international cooperation in a variety of projects (although some domestic water reallocation with accompanying structural changes of the agricultural sectors is a likely part of any efficient solution; Frederick 1993). Given the growing dimensions of scarcity, international cooperation in water resource development appears to be imperative. International water cooperation, however, will involve both high initial investments in infrastructure, and an increase in international good will and technological interdependency.

Water Allocation by Markets Versus Bargaining. The creation of water markets is widely propounded as a means of achieving economic efficiency in water resource allocation within jurisdictions. Similarly, establishment of international water markets is often proposed as a means of facilitating efficient trans-boundary water reallocation and establishing incentives for development of international water projects. However, as experience in many forms of international trade has shown, international markets are not likely to operate free of regulations and restrictions that reduce the efficiency of competition.

In addition, water markets require institutions, laws, regulations, financial arrangements, specific capital investments, monitoring capability, and quality control. Currently, most of these institutional features do not fully exist in trans-boundary Middle East water problems. The presence of transaction costs and the specificity of capital related to water projects in absence of stable institutional infrastructure are likely to decrease the cost advantages of markets and increase governance costs.

Finally, international water projects that enhance water supply typically carry high investment costs in specific capital items that have few alternative uses. When assets become semi-specific, bilateral contracting becomes preferable to market arrangements, and when assets become highly specific, an internal organization dominates free markets (Williamson 1981). In the context of Middle East water problems, these results suggest that governments should negotiate contracts for reallocation of water resources and development of new international water projects because of the highly specific nature of required capital investments. In other words, bargaining appears to offer a more suitable mechanism than water markets for facilitating international water cooperation. Moreover, bargaining may be the only initial means of facilitating water transfer given the current lack of effective trading relationships.

Increasing opportunities for voluntary Middle East water cooperation among Israel, Jordan, and the Palestinians have surfaced as a result of recent peace talks and agreements. These opportunities are broadened by World Bank involvement (in research, data collection, and funding) and have attracted academic interest including research groups at the University of Pennsylvania, the Kennedy School at Harvard, the Hammer Fund, the Foerder Institute, the Sapir Center for Development at Tel Aviv University, and Ben Gurion University. Recent research results are reported by Naff and Matson 1984; Lowi 1993; Clarke 1993; Beschorner 1992/93; Kally 1993; Soffer 1992; Kliot 1994; Eckstein, Zakai, Nachtom, and Fishelson 1994; and Zeitouni, Becker, Shechter 1994; among others. Many conferences are also contributing to the debate including those in Kfar Blum (1992), Zurich (1992), Waterloo (May 1992), and Cyprus (July 1994) to name a few. However, no general agreement among Israel, Jordan, Lebanon, Syria, and the Palestinian Autonomy (all of which claim rights over the Jordan Basin) appears to be close. While some partial agreements have been reached for parts of the Basin, the potential of limiting future bargaining positions deters piecemeal bilateral agreements.

<u>Disputes and Disagreements to Date</u>. Before discussing the potential for international cooperation in water resource development, a short history of experience to date is useful. This discussion is facilitated by an overview of the water resources in the region. The upper Jordan

and its tributaries originate in Israel and Lebanon. Jordan, Syria, and the Palestinians also have interests in the River's flows. The upper Jordan flows into Lake Kinneret (also known as the Sea of Galilee and Lake Tiberias) which captures about 500 million cubic meters per year (mcm/yr) (Kally 1993). Water from the Kinneret is diverted into the Israeli National Water Carrier. The upper Jordan River is fed by three main sources: Dan Spring in Israel (250 mcm/yr), the Hasbani River which is fed by springs in Lebanon (85-105 mcm/yr) and Israel (45 mcm/yr), and Hermon (Banias) Spring in the Israeli-annexed Golan Heights, which prior to 1967 was part of Syria (110-120 mcm/yr).

The main tributary (40 kilometers in length) in the Basin is the Yarmouk River which forms part of the Syrian-Jordanian border upstream and the Jordanian-Golan Heights border downstream. The Yarmouk River joins the Jordan River 10 kilometers below the Kinneret. Syria and Jordan use the Yarmouk River to irrigate about 15,000 hectares and 13,800 hectares, respectively. Syrian and Jordanian flows into the Yarmouk account for 375 mcm/yr and 100 mcm/yr, respectively. Two other water sources in the Jordan Basin are the Eastern Rim (South Yarmouk) that originates in Jordan (200-220 mcm/yr) and the Western Rim (South Sea of Galilee) that originates in Israel (45-55 mcm/yr).

In the lower part of the Jordan River, irrigation returns from both sides of the bank feed into the Jordan River below the Kinneret before it discharges into the Dead Sea. These flows are heavily polluted. In addition, Israel diverts saline springs to the lower Jordan River which would otherwise pollute the Kinneret and more than double its chloride level. For example, about 16.25 mcm were diverted in 1992 (Hydrological Service, 1994). The costs associated with improving this low quality water prevent the riparian countries from exploiting lower Jordan River waters.

Historic-use rights in the Jordan Basin are extremely complex, as they are throughout the world. Johnston, who was President Eisenhower's personal representative to the Jordan River Valley Development Project authored a water plan for the Middle East which, although accepted by Basin experts, was never carried out (Johnston 1954). However, a partial agreement based on Johnston's plan exists between Israel and Jordan, where the United States serves as mediator. The Johnston Plan for Yarmouk River water allocated 275 mcm/yr to Jordan, 90 mcm/yr to Syria, and 25 mcm/yr to Israel. Jordan now uses 120 mcm/yr, Syria 170 mcm/yr, and Israel 100 mcm/yr. Israel uses virtually all of the 500 mcm/yr captured by Lake Kinneret from the upper Jordan River.

The problem in implementing the plan is that "rights" bear little weight in the absence of the means and infrastructure to use them. For example, Syria as an upstream user has been able use more than its share. Jordan, on the other hand, has not had sufficient infrastructure to use all of its allocated water. Finally, Israel uses the Yarmouk at its lowermost end and has been able to use more water than allocated under the Johnston plan because the sum of Syrian and Jordanian use has been less than planned. With respect to the Jordan River, Israel has been able to exploit virtually all of the capacity because salinity problems in the lower Jordan and lack of alternative transportation facilities from the upper Jordan/Kinneret prevent access by Jordan.

Not surprisingly, countries dispute the current share allocations. Jordan does not accept the current level of water use by Israel. Israel, on the other hand, demands an additional 140-150 mcm/yr from Yarmouk water to be used by the Palestinians residing in Judea and Samaria which were under Jordanian responsibility when Johnston's plan was written. Jordan opposes Israel's demand and the United States supports Jordan in the matter (see Fisseha, 1981, and Soffer, 1992, for further discussion).

In addition to the Israeli-Jordanian conflict, Syria and Lebanon reject Johnston's plan and some of Israel's rights to Jordan-Yarmouk water. Syria claims rights to the Banias as part of its claim on the Golan Heights, and Lebanon demands rights to the Hasbani in the Israeli Security Zone. Additionally, Palestinians dispute Israel's pumping of water emerging in the coastal plain from the Yarkon-Tanninim aquifer that originates in Judea and Samaria (Lowi 1991). This dispute is indirectly related to the Israeli-Jordanian conflict over water in the Jordan Basin and adds to the tension among countries in the region. (For a summary of the history of water conflict and cooperation in the area, see Kliot, 1994, and Wolf, 1993.)

During the long period of these disputes, several changes have opened possibilities for renegotiating Jordan-Yarmouk water allocation. Lebanon's economy does not depend on Jordan water. Thus, possibilities likely exist for transferring its rights in return for adequate compensation. Southeastern Syrian agriculture is heavily dependent on water and would likely be reluctant to give up rights although Syria has a major alternative water source in the Euphrates River. Jordan depends heavily on water in the Jordan Basin but its position is relatively inferior because it is located in the lower part of the Basin and presently has little control over quantity or quality of the water. Finally, Israel is unlikely to give up rights because the Jordan supplies up to 25-35% of its water (Soffer 1992; Naff and Matson 1984; Shamir, Bear, and Arad 1985; Kliot 1994).

Although negotiation among countries seems to be unavoidable, political barriers complicate the process substantially (LeMarquand 1977). Many potential projects hold promise for improving water availability and permitting reallocation. However, costs in terms of financial investment, time to establish infrastructure, and dependency on other countries constitute crucial obstacles.

Potential International Water Projects. With negotiation and cooperation among riparian countries, several trans-boundary water projects have potential to ease current water constraints. A number of such projects are listed in Table 1. Two of the most important possibilities which are considered further in this paper for illustrative purposes are as follows.

1. Diversion of Yarmouk River Water to Lake Kinneret. Currently Jordan exploits the Yarmouk's summer flow to irrigate the Ghor Valley leaving a substantial quantity of winter floodwater unutilized. Several research projects (Ben-Shahar, Fishelson, and Hirsch 1989; Kally 1993) suggest that the most economical regional water project is to construct a canal to divert winter floodwater from the Yarmouk River to Lake Kinneret. The water would be diverted back to the riverbed through a second canal during the summer to facilitate flow by gravitation to the Ghor Valley. Because the Yarmouk River lies in Jordan and the Kinneret lies in Israel, however, international cooperation between the two countries is necessary.

Under this plan, 80-100 mcm/yr out of the 180 mcm/yr of the Yarmouk water captured in the Kinneret would be allocated to Jordan. However, the remaining share of the 180 mcm/yr, currently unutilized by Jordan due to capacity limitations of the Ghor Canal, could be transferred by Israel to storage in the coastal aquifer. This water could make up for the water deficit currently occurring in the coastal aquifer, which is becoming salinized due to overuse. Alternatively, Israel's share of the water could be diverted to the National Water Carrier in peak-demand periods in lieu of coastal aquifer water diversion. But this may require widening the National Water Carrier.

This project apparently offers lower cost additional water than other proposed project (Table 1). To demonstrate the potential benefits of the project, note that the cost of the proposed project is approximately \$28 million.[1] Assume that water at its point of use is valued at, say, an average of \$0.20/cubic meter (cm), which corresponds roughly to a weighted average of marginal prices in Israel over uses in agriculture, industry, and households. Transportation costs to Jordan from Israel are approximately \$0.08 (Fisher 1994). Transportation costs to Israel from Jordan are at most \$0.05 (Eckstein *et al.* 1994). If Jordan receives 80 mcm/yr and Israel receives 100 mcm/yr, then total net benefits would be \$24.6 million/yr. Thus, net benefits from the project are highly positive. Investment costs are almost recovered in a single year of operation.

The project also yields quality and other reduced-variability benefits. Chloride levels in the Kinneret which captures roughly 500 mcm/yr had reached 248 parts per million by 1991 (Hydrological Service 1994). By running an additional 180 mcm/yr of high quality Yarmouk water through the Kinneret, its salinity would be reduced by 20% (Ben-Shahar, Fishelson, and Hirsch 1989). Since the value of water is a downward-sloping, concave function of salinity (at low levels of salinity), such an averaging of qualities is preferred. Reduced-variability benefits are possible because storage in the Kinneret can not only increase summer flows, but make them more uniform throughout the growing season and, to a lesser extent, across years.

2. Construction of the Jordanian/Syrian Unity (Wahda) Dam. Construction of a dam on the upper Yarmouk River has also been proposed as a means of stabilizing water flows. To stabilize flows, currently unused water flows in the high-flow winter season would be captured by the dam and released during summer. The water would be released directly into the River and then channeled into the Ghor Canal downstream. The Kinneret alternative for storing

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[1] The reported cost is \$21 million in 1983 dollars (Kally 1993). Note that values and prices are stated in 1990 dollars throughout the paper. We use the GDP price deflator (IMF, 1993) to convert prices to 1990 dollars. All water prices are per cubic meter.

floodwater is significantly cheaper than building a dam but the political infrastructure for cooperation between Syria and Jordan was much stronger than between Israel and Jordan when the Unity Dam was first considered in 1987.

The currently proposed Unity Dam is a scaled back version of the much larger but considerably more expensive Maqarin Dam that had been proposed earlier. This dam would require Jordanian-Syrian cooperation because it would be located on the Yarmouk River where it serves as an international border between Jordan and Syria. The dam would generate not only water storage and regulation facilities but electricity generation capacity. Because of Syrian and Jordanian infrastructure and terrain, the additional water would be most profitably used by Jordan whereas Syria would benefit from electricity generation.

The World Bank has a loan pending to finance building the Unity Dam, but the loan can be granted only if Israel removes its objection. The Yarmouk River currently contributes from 3% to 7% of Israel's national water supply and the dam project could threaten Israel's ability to meet growing water demands (see Starr, 1992). One possibility for negotiating a removal of Israel's objection and thereby freeing pending loans and investments is to offer a share of the associated additional water resources to Israel. According to Shuval (1992), an agreement among Israel, Jordan, and Syria was negotiated unsuccessfully prior to the 1991 Gulf War under U.S. guidance.

One problem with the Unity Dam proposal is its expense ($500 million). The capitalized cost of additional water provided by the dam is above the current agricultural use value. Estimates for the capitalized cost of Unity Dam water are $.26-.45/cm. If users had to bear this full cost, the water would not be used for agricultural production in the Ghor Valley, Jordan's main agricultural area. However, water at this price would be considerably below the estimated market clearing price in other sectors and regions which exceeds $1.00/cm (World Bank 1994). Furthermore, with sufficient construction subsidies from international agencies, use for Ghor Valley agriculture may also become attractive privately.

Summary. In view of mutual incentives for international projects, most notably between Israel and Jordan on the Yarmouk-Kinneret canals, and the increasingly desperate condition of water particularly in Jordan, the potential for cooperation appears to be enormous. However, any useful approach to cooperation must take account of non-economic and non-efficiency objectives of all participating parties sufficiently to generate incentives to cooperate and sustain cooperation (Biswas 1993). Obviously, these benefits of cooperation can only be gained if agreements provide positive benefits to all cooperating countries and a fair distribution of the benefits between countries.

3. Potential for Cooperation in the Jordan Basin[2]

Mutual Incentives for Israeli-Jordanian Cooperation. Consider first potential cooperation on the proposed canals connecting the Yarmouk River, the Kinneret, and the Ghor Valley (Table 1). This project contains two important components each of which provides benefits for one of the cooperating parties. One canal carries currently unutilized water from the Yarmouk River increasing Israeli water supply. The other canal carries part of the water back to Jordan at a time when Jordan can make use of it thus increasing effective Jordanian water supply. Both parties have incentives to cooperate. Apparently, current infrastructure limitations of the Ghor Canal would allow Jordan to use only 80 mcm/yr (in addition to its current use) leaving Israel free to use the other 100 mcm/yr.

[2] Details on the applications of bargaining theory to Israeli-Jordanian cooperation discussed in this paper can be found in Just, Horowitz, and Netanyahu (1994).

Pursuing "half" of the proposed project by building the canal from the Kinneret to the Ghor Canal (without building the canal to divert water from the Yarmouk River) would allow Jordan to have access to the Kinneret. But Israel's historic-use rights to that water apparently preclude Jordan's use of any of the existing water. In addition, valuable winter flood water would continue to be wasted. Similarly, pursuing the other half of the proposed project by building a canal diverting Yarmouk River water to Israel without providing for a return of water to Jordan only provides one-sided benefits for Israel. Jordan would have no incentive to reduce its claim to Yarmouk River water even though some of it is unused. A potential bargain can be negotiated by combining and balancing these one-sided benefits so that individual benefits to each country are agreeable.

<u>Implications of Bargaining Theory for Cooperation on the Kinneret-Yarmouk Project.</u> Prospects for determining a fair and agreeable bargain can be investigated using game theory. Results from game theory show that if certain standard axioms are satisfied and a bargaining solution can be reached, then it must be the Nash bargaining solution.[3] This sections considers implications of the Nash bargaining solution for sharing the benefits of a Yarmouk River diversion project. To use this framework with limited empirical information, we consider some initial plausible assumptions and then examine sensitivity to assumptions. The implications of the solution are robust with respect to assumptions so this approach is informative.

To illustrate, suppose elasticities of water demand are .25 in both Israel and Jordan under current marginal pricing schemes. Consider weighted average current prices of \$0.25/cm in Israel and \$0.40/cm in Jordan with aggregate current water quantities of 1700 mcm/yr in Israel and 880 mcm/yr in Jordan. Now consider Israeli-Jordanian bargaining over a new 180 mcm/yr

[3] These axioms require the parties to be rational and treated symmetrically, and that the result is independent of irrelevant alternatives and not affected by linear transformations of each parties preferences.

of water. Total water supply is then 1700 + 880 + 180 mcm/yr. The Nash bargaining solution of this problem is an equal split of the additional Yarmouk water, with 90 mcm/yr for each party.[4] The equal-split solution is surprisingly robust to changes in demand elasticities and to changes in assumptions about the current prices of water. An exactly equal split is predicted for a large range of parameter values.

If a feasibility constraint is added reflecting that the Ghor Canal can handle only 80 mcm/yr of additional water, then the constraint is binding. As a result, Jordan gets 80 mcm/yr and Israel gets 100 mcm/yr. Again, this solution is insensitive to assumptions on parameter values. This constrained solution increases water supply by 6% in Israel and 9% in Jordan. Simple analysis of demand implies that this change will decrease the marginal value of water by

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[4] Mathematically, water demands under these assumptions follow

$$p_i = \beta_i q_i^{-\alpha_i}, \qquad p_j = \beta_j q_j^{-\alpha_j}$$

where i denotes Israel and j denotes Jordan. Using these demand functions, the benefits derived from water for the respective countries follow

$$U_i = \frac{\beta_i q_i^{1-\alpha_i}}{1-\alpha_i}, \qquad U_j = \frac{\beta_j q_j^{1-\alpha_j}}{1-\alpha_j}.$$

Reservation utilities for purposes of bargaining, $\bar{U}_i$ and $\bar{U}_j$, are calculated by substituting current use levels in these expressions using existing water use levels. Under the assumptions above, $\alpha_i = \alpha_j = 0.25$, $p_i = \$0.25$, $p_j = \$0.40$, $q_i = 1700$ mcm/yr, $q_j = 880$ mcm/yr, $\beta_i = 1.61$, and $\beta_j = 2.18$. The Nash bargaining solution is obtained by maximizing

$$\left[\frac{\beta_i q_i^{1-\alpha_i}}{1-\alpha_i} - \bar{U}_i\right]\left[\frac{\beta_j (K-q_i)^{1-\alpha_j}}{1-\alpha_j} - \bar{U}_j\right].$$

where K = 1700 + 880 + 180 mcm/yr.

about 2% in both countries. Fisher (1994) draws a similar conclusion.

Stability of the Cooperative Solution. As this example illustrates, physical constraints caused by available infrastructure can play a significant role. If the Ghor Canal can handle no more than an additional 80 mcm/yr and the marginal value of water is higher in Jordan than Israel, then this constraint is binding for a large range of parameter values. The robustness of the unconstrained solution, on the other hand, is related to the assumption of equal elasticities of demand in the two countries. This condition may not hold.

If the Ghor Canal capacity is limited and the marginal value of water in Jordan is higher than in Israel, then the game theory solution is the same as the water markets solution. In both solutions, the capacity constraint is binding. If the capacity constraint is not binding, however, then the solutions can be quite different. The water market solution would allocate all of the additional water to the country with highest marginal value of water compared to the Nash bargaining solution where allocations are equal. This suggests that future investment in water transportation infrastructure in the Jordan Valley could cause a future conflict in water allocation once the Yarmouk canals are in place. This is one reason why Jordan may have been reluctant to negotiate an international agreement with Israel.

This case also illustrates why a market solution may be unacceptable in a trans-boundary water problem. A market solution typically allocates all of an increase in water availability to the country with the highest marginal value of water. Understandably, countries are reluctant to give up all of their claim to a constraining resource given uncertainties about future contingencies and demand growth.

How well any agreement will perform depends on continuing incentives to follow its provisions. Further consideration of strategic behavior that may become advantageous once investments are in place reveals further potential problems that may be forestalling an agreement. That is, Israel may have a greater opportunity and higher incentives than Jordan to renege on any cooperative agreement once investments are in place. Jordan has little incentive to divert less than the 180 mcm/yr because the water is currently unutilized winter flood water. Jordan can get increased summer water only by carrying through with the agreement.

The incentive not to adhere to the agreement may be larger for Israel. Once the water is captured, Israel could refuse to divert the entire agreed-upon amount back to Jordan. Israel could justify its action by arguing that Jordan was wasting the water and that the higher value use was in Israel. Such an argument would be difficult to verify and difficult to refute. Retaliation by Jordan would have to take place the following season and would not be credible because Jordan gains nothing from not diverting the water as long as Israel is sending back some substantive share of the agreed amount. These considerations suggest another reason why Jordan may have been reluctant to negotiate an international agreement with Israel. Protection against this type of conflict is best considered before investment takes place. In fact, without such protection, an agreement may never be reached.

Prospects and Problems Associated with Multilateral Cooperation. Another obstacle to cooperation on the Yarmouk-Kinneret canals is that benefits and incentives for cooperation may be significantly affected by the Unity dam on the upper Yarmouk. The Unity Dam promises to deliver an additional 225 mcm/yr of water to Jordan (in addition to electricity to Syria) at a capitalized cost of $0.34/cm (See Table 1). This cost is higher than the cost of water made available by the Yarmouk-Kinneret canals, but the cost appears to be lower than the current marginal value of water in Jordan and Jordan's vulnerability to strategic behavior of another country is less. Because Syria and Jordan could each benefit from the dam and it is located on a common border, vulnerability to ex post strategic behavior does not appear to be a problem. Apparently, only Israel's objection is a major obstacle.

From Jordan's viewpoint, the dam provides a substitute for the Yarmouk-Kinneret canals. If the Unity Dam were already in place, the value to Jordan of the canals is close to zero. On the other hand, if the Yarmouk canals were already in place, the value to Jordan of the Unity Dam is much less and possibly close to zero because the dam's capacity exceeds the capacity of the Ghor Canal.

From Israel's viewpoint, the Unity Dam is important only if it affects the construction of the Yarmouk-Kinneret canals. If the dam is constructed before the canals, then the value of the canals derives solely from the value of the water to Israel. This value is smaller than the value when both Jordan and Israel use the project, but the project still would be likely to pass a benefit-cost test. In this case, Jordan's incentive to cooperate with Israel must derive from other means such as monetary compensation. More importantly, once both projects are constructed, Israel becomes subject to strategic behavior by Jordan.

For Israel to receive water, Jordan must divert water that it will not use. If an international agreement is likely to be carried out as agreed, then Israel would presumably be willing to support the Unity Dam in lieu of the canals if it were guaranteed 100 mcm/yr at costs comparable to the canal cost. Presumably, Jordan would be willing to agree to this amount given current Jordanian capacity in the Ghor Canal. However, consider strategic behavior that becomes possible once either both projects are in place or once the Unity Dam is in place. In this case, the water could be diverted either during the summer, after storage behind the Unity Dam, or during the winter, in which case the water would have passed through potential upstream storage at the Unity Dam. Because Jordan would already have storage capacity in this case, there would be no point to shipping water into the Kinneret for later return to Jordan. Furthermore, Jordan would have no incentive to continue shipping water to Israel unless other forms of compensation were developed. Jordan could simply renege on the agreement without consequence. Furthermore, if Jordan were to increase its capacity for utilization, say, by expanding the Ghor Canal, then Jordan would face an incentive to break the agreement to provide water to Israel.

These considerations demonstrate how future contingencies can change incentives to participate in agreements once fixed investments are made. Anticipation of these consequences explains why parties have been unable to reach agreement on projects that offer substantial net economic gains. Israel refuses to remove its objection to the Unity Dam because that would give Jordan a strategic incentive to break any agreement acceptable to Israel. Jordan refuses to participate in the Yarmouk-Kinneret canals because that would give Israel a strategic incentive to break any agreement acceptable to Jordan. Project designs are needed that not only offer economic gains but provide sufficient incentives to follow through on agreements once investments are in place, i.e., build in sufficient remedies for each side to make strategic behavior unattractive to the other.

4. Potential Cooperation between Israel and the Palestinians on the Mountain Aquifer

<u>The Mountain Aquifer</u>. Use of the Mountain Aquifer in Israel represents another important trans-boundary water problem. The Mountain Aquifer lies under the mountains of Judea and Samaria. It consists of two hydrologically disconnected basins: the Yarkon-Taninnim (YT) Basin and the Eastern Mountain (EM) Basin. A large portion of water caught in this area emerges in a long line of springs within Israel extending from the Tanninim to the Yarkon in

the YT Basin. The YT Basin includes six sub-aquifers collectively called the Western Aquifer. Maximum sustainable yield is 350 mcm/yr. The two aquifers of the EM Basin underlying Judea and Samaria are the Eastern (sustainable yield of 125 mcm/yr) and Northern (sustainable yield of 140 mcm/yr) Aquifers (Lowi, 1993).

In recent years, an average of 331 mcm/yr has been pumped from the YT Basin, and an additional 51 mcm/yr has been used from YT spring flows (Hydrological Service, 1994). Use of the YT Basin has historically been dominated by Israel. On average, Israel has used 362 mcm/yr and Palestinians have used 20 mcm/yr (Lowi 1993, Isaac, et al., 1994). The quantity consumed by Palestinians has not changed substantially since 1967 (Gvirtzman, 1994). Israel has also been the primary user of the Northern Aquifer of the EM basin. Palestinians have relied mainly on the Eastern Aquifer. Total Palestinian pumping from all 3 sources has averaged 100-125 mcm/yr. Pumping quotas allotted to Palestinians by the Israeli Civil Administration totaled 125 mcm/yr in 1990. Only a small margin for growth in personal use has been permitted. Jewish settlers have pumped 40-60 mcm/yr mainly from the Eastern Aquifer.

Israel's exploitation appears to be slightly higher than the maximum sustainable yield.[5] However, current information regarding maximum sustainable yields is subject to uncertainties so it is difficult to determine how much each of the aquifers are currently being overdrawn. More importantly, it is not clear how the quantity withdrawn from one sub-aquifer affects the sustainable yield of the other sub-aquifers within each of the two Basins. For example, if less water were withdrawn from the Northern Aquifer, perhaps more water could be sustainably

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[5] There appears to be some salinity in the south due to overpumping in southwestern margins of the Basin, and in the north due to transport of saline water from the center. This salinity is apparently the result of pumping beyond the maximum sustainable yield.

pumped from the Eastern Aquifer.

Water rights are disputed. The question is how much water each of the parties should extract and whether Israel should compensate the Palestinians for Israel's pumping from the YT because this water originates in Judea and Samaria. Agreement between Israel and the Palestinians may be more difficult to achieve than in the Israeli-Jordanian cases above because the contested groundwater is harder to monitor and unforeseen (and unverifiable) problems may arise in its extraction. Also, the hydrology of the region does not establish a clear "owner" or even a hierarchy of use rights.

In the higher elevations and on the eastern slope, which is where Palestinian water supplies are drawn, extraction can be quite costly and is an increasing function of the amount pumped. Pumping costs also increase as the amount of water remaining in the aquifer decreases. Depending on location, pumping costs are $0.16/cm to $0.34/cm (Fisher, 1994). By comparison, the wells in the lower-elevation YT Basin where Israel draws water are gravity fed and offer stable and less expensive pumping (Gvirtzman, 1994). Pumping costs range from $0.15/cm to $0.20/cm (Fisher, 1994). As a result of this relationship, Israel's pumping costs are largely unaffected by Palestinian water use, but Palestinian pumping costs appear to be increased, even in the short run, by Israeli withdrawals. Therefore, Israel appears to impose a pumping cost externality on the Palestinians.

Implications of Bargaining Theory for Cooperation on Aquifer Withdrawal. Again, bargaining theory offers insights into efficient and equitable solutions. An efficient solution would likely include a tax on water pumped by Israel that would compensate Palestinians for increased pumping costs. Nevertheless, Israel would extract and use most of the water because of its lower extraction costs and higher valued use. Regardless of whether such a compensation scheme is implemented, the parties must reach agreement on ownership rights of the groundwater. This section considers the application of bargaining theory to the Israeli-Palestinian problem in the YT Basin of the Mountain Aquifer.

To simplify the problem, suppose the parties agree to extract no more than 350 mcm/yr, the maximum sustainable yield, and that Israel can extract up to this amount at a cost of \$0.15/cm. Suppose Palestinians extract water at an average cost that increases in both Palestinian and Israeli pumping. Then suppose bargaining is undertaken to determine the amount of the unit charge and the quantities used by each party.

Setting reservation utilities (below which each party would prefer not to have an agreement) at levels corresponding to current use after deducting user costs associated with future implications of present over-pumping, the Nash bargaining solution is for the Palestinians to pump 122 mcm/yr and for Israel to pump 228 mcm/yr and pay a charge \$0.07/cm.[6] The marginal cost for the water extracted by Palestinians is then \$0.39/cm. The solution is only mildly sensitive to the overall pumping constraint. If the pumping constraint is relaxed, Israel

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6 Specifically, suppose the Palestinian cost of pumping water quantity q_P follows

$$c(q_p,q_i) = \alpha q_i q_p + \gamma q_p^2$$

and suppose Israeli and Palestinian benefits from water are represented by

$$U_i = \frac{\beta_i(Q_i+q_i)^{1-\alpha_i}}{1-\alpha_i} - \tau q_i - .15 q_i, \quad U_P = \frac{\beta_P(Q_p+q_P)^{1-\alpha_P}}{1-\alpha_P} + \tau q_i - c(q_p,q_i),$$

respectively. In each case, the first term represents consumer surplus for constant elasticity water demand, the second term represents the charge paid by Israelis to Palestinians, and the third term represents the respective party's cost of pumping. The parameter values used for the example are $\alpha_i = .407$, $\alpha_P = 0.44$, $\beta_i = 7.81$, $\beta_P = 4.29$, $\gamma = .00128$, and $\alpha = .0003347$. These parameter values are based on an average of Fisher's (1994) sectoral demand elasticities weighted by sectoral uses. For further justification and discussion about the representation of user costs in the reservation utilities, see Netanyahu, Just, and Horowitz (1994).

pumps more at least in the short run but the externality imposed on Palestinians also rises, as does the charge. Unlike the Israeli-Jordanian problem, however, this solution is sensitive to both Israeli and Palestinian pumping costs and the reservation utilities. Furthermore, reservation utilities are harder to model in this case because current (noncooperative) extraction levels are not sustainable. Ideally, the reservation utilities should reflect Palestinian ability to exercise ownership in the absence of any trans-boundary agreement. .

Stability of the Cooperative Solution. As with the Yarmouk-Kinneret canal project, watershed geography drives most of the solution. If Israel can extract 350 mcm/yr from the YT springs at minimal cost and if Palestinian use is more costly, almost any solution will allow Israel to extract most of this amount. Furthermore, the low elevation user of an aquifer, like the upstream user of a river, has first claim on the water when no agreement or control is in force. Thus, more precise modeling of the reservation utilities would likely further favor allocating most of the water to Israel.

In this case, the bargaining solution does not differ radically from a market solution. With a market solution, Israel should compensate the Palestinians for the externality that Israel's extraction imposes on Palestinian pumping costs. This charge is likely small as in the bargaining solution. Additionally, an efficiency solution would address the common-property overuse of the aquifer by means of a tax or quota on pumping paralleling the quota imposed in the bargaining solution.

Again, however, the bargaining analysis reveals that the solution may not be stable given the incentives for cooperation by the individual parties. It is not clear that either party would have sufficient incentive to abide by the agreement even if an appropriate pumping limit could be determined. First, both parties have an incentive to renege because monitoring is difficult.

Since Israel's pumping is at low cost, it can deviate with little consequence. Palestinian deviation is not as advantageous because its future pumping costs are raised thereby. Further understanding of these considerations requires a noncooperative model. Clearly also, this example as well as the others points out that a market allocation of water benefits may be so one-sided that international conflicts cannot be resolved thereby. This difficulty of negotiation is illuminated by a game theoretic analysis. For further discussion, see Netanyahu, Just, and Horowitz (1994).

5. Current Water Situation in Israel

Overview of Water Pricing and Allocation. The remainder of this paper turns to water allocation problems within individual countries. Clearly, the value of water forthcoming from international projects depends on how it is allocated within individual countries because different users pay different prices. Thus, the value of additional water cannot be divorced from how water is allocated within individual countries. This analysis also reveals a comparison of the value of improved internal allocation with the value of improved water availability through international projects. This section looks at the current water situation in Israel. These considerations are then taken into account in assessing the marginal value of water for Israel.

The Israeli economy can be divided into three sectors for the purposes of discussing water use: domestic (households), agriculture, and industry. Prices paid by each of these sectors for water in 1990 is shown in Table 2. Each sector faces its own block tariff schedule for water. A similar price schedule has been in effect every year since 1990. Farms and some industrial firms have allotted quotas. They can, in general, use more than their quota but must pay a higher price for over-quota use for which availability is not guaranteed.

The price schedule and observed agricultural demands together demonstrate that the marginal value of water in agriculture may have declined between 1990 and 1992 (Table 3). During this same period, the real price of water (at each quantity) rose by 33%, reducing the indirect water subsidy. However, many farmers apparently attained a lower water price by reducing water use relative to their quota. If water use in 1994 is similar to 1992, then the current (national average) marginal private value of water in agriculture could be as low as \$0.12/cm in 1990 dollars.[7]

It is not hard to understand why the private value of water may have declined in agriculture; it is due to more efficient irrigation. Whether agricultural demand for water at any given price will continue to decline depends both on opportunities to expand the use of currently available technologies and on what new technologies are discovered. The degree of accessibility to the European market may play a role as well. The demand curve could shift out if product prices rise, but product prices are likely to be less important than changes in irrigation technologies.

Differences in water prices among sectors suggest that sector incomes are weighted differently in policy formulation. If each of the three sectors is characterized by constant elasticity demand (Fisher 1994), then the implicit relative weights are 2, 1.7, and 1 for agriculture, industry, and households, respectively.[8] Typically, the differences in weights among sectors is attributed to differences in political power of individual sectors. Alternatively, the

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7 This is the proposed price for 1994 in 1990 dollars (Mekorot, December 1993).

8 With stated elasticities, the multiplicative constant terms corresponding to 1990 use levels are 1200, 100, and 450 mcm/yr at prices \$0.17, \$0.20, and \$0.34 for the three sectors, respectively (Water Commission 1994). These prices correspond to current prices where household water is valued at municipality gate prices. The implicit relative weights are determined by choosing weights such that observed quantities (or prices) maximize a weighted sum of sectoral water benefits.

higher weight on agriculture may reflect a long-standing priority to support food self-sufficiency based on war-time conditions. Similarly, the higher weight on industry relative to households may be motivated by an infant industry argument. Considering the benefits to future generations of economic development, subsidies for industry may be economically rational. Furthermore, household water charges are a major income for the municipalities. Part of the higher price to households may be a form of taxation to provide residential public goods.

Domestic Trans-Boundary Water Allocation Issues. The percentage of quota used by farmers varies substantially by region (Figure 1). Given the increasing block rate pricing structure, this imposes a regional variation in water prices following Table 3 as well. What explains these regional differences in pricing and what are the prospects for more economical pricing and allocation? With efficient allocation, prices among regions should differ by no more than the costs of transportation. However, the price differences suggested by Figure 1 are hard to explain on the basis of costs of water transportation. The highest prices are being paid along the National Carrier closest to the source waters of Lake Kinneret.

Typically, inefficient water price variations (usually among sectors) have been explained by political power of advantaged groups. However, this variation in prices does not appear to be consistent with a political power explanation because it does not favor the concentration of farmers in the Northern Coastal regions. Alternatively, this variation in prices is consistent with setting water quotas so as to provide lower water prices in regions where settlement is a national goal. Interestingly, the regions which use less than 80% of quota (and thus pay the most favorable agricultural water price) have been the remote regions in which the government has encouraged settlement over the past few decades for national security and development reasons. The regions which use over 100% of quota (and thus pay the highest agricultural water price) are the most secure regions of the Northern Coast.

A further analysis of quota variations among regions also tends to support this conclusion. If quotas represent true water availability, then the regional use pattern in Figure 1 suggests the possibility that water is over-allocated and questions whether water is in shortage at all. Comparison of use to quota shows that water is available in surplus in the Arava and the Negev regions of the South and only in shortage in the Northern Coast. However, the layout and direction of flow in the National Carrier and associated pipelines suggests that reallocation toward the North is possible and less costly so that Northern shortages need not exist.[9]

Alternatively, if quotas are assigned, at least partially, to provide subsidies to settlement of remote areas, then comparison of water use to quotas is meaningless as an assessment of water shortage. As evidence in favor of this interpretation, note that water use in the Arava is filled primarily from groundwater and groundwater in the Arava has been overdrafted, i.e., used beyond sustainable levels (Ministry of Agriculture 1994; The Hydrological Service, 1994), at the same time that use has been below quota (Figure 1). Thus, at least in the case of the Arava, the quota apparently does not reflect true supply. Alternatively, the quotas are high relative to use levels offering a substantial incentive encouraging settlement of a remote area.

6. Current Water Situation in Jordan

Water Shortages and Limited Potential for Market Allocation. Some aspects of water

[9] The possibility exists that local use and availability patterns make reallocation infeasible. For example, some farms are connected by local pipelines to the National Carrier, but some are not. Excess supply may be associated with unconnected farms. However, supply of fresh water in the remote regions of the South comes primarily from groundwater for which availability conditions are broadly applicable. At least at the margin, reallocation should be possible by simply shipping less water down the National Carrier. Differences in water quality might also explain why seemingly feasible reallocation cannot be carried out profitably. However, approximately 70% of farm water use is relatively high quality surface water so adjustment at the margin appears to be feasible in this case as well. Industry uses a similar mix of water qualities (Tahal 1990).

allocation in Jordan are similar to Israel. Industry and households connected to the water system in the Jordan Valley pay for water and sewage according to a block tariff structure much like in Israel. However, households and industry face identical price schedules as shown in Table 4. Moreover, water supplies are erratic. Firms and households are not necessarily able to purchase the water they want at stated prices. On some days, no water is available at all. Therefore, determining the marginal value of water is difficult. A recent World Bank publication (1994) suggests that the market clearing price in the Highland is higher than $1.00, but less than the $4.50 charged by private water tanker owners. This very high marginal value of water suggests why an international water market linking Jordan and Israel would tend to allocate new sources of water entirely to Jordan.

As in Israel, the marginal value of water is higher in nonagricultural uses than in agriculture.[10] Reallocation away from agriculture would likely require compensating farmers as well as determining the allocation (or rationing) of remaining water. The establishment of a water market for farmers could improve efficiency of allocation. However, developing an effective water market in Jordan would involve substantial costs for infrastructure to facilitate monitoring and repair of leaky canals.

Moreover, reallocation of water away from the agricultural sector may contradict other national goals. As in the case of Israel, the subsidy for agriculture is possibly rooted in a national interest in food self sufficiency that takes precedence over water issues. Objectives have been to turn the fertile land of the Jordan Valley into the breadbasket of Jordan (Lowi, 1993). Moreover, reallocation of water away from the agricultural sector apparently contradicts other national goals related to the development of the Jordan Valley for the settlement of refugees.

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[10] For example, farmers have water on days when the cities do not, and when water is available farmers pay a price below the nonagricultural price.

Therefore, inter-sectoral and inter-regional price equalization may be an inappropriate water policy. Alternatively, means are needed for improving efficiency of water allocation in the context of these national goals.

Domestic Trans-Boundary Water Allocation Issues. Unlike in Israel, little infrastructure exists to permit inter-regional water transfer. To the extent that sectoral activity is regionally based, possibilities for inter-sectoral reallocation are also limited. There are two hydrological areas: the Highland and the Jordan Valley. In the Highland, farmers are not connected to a water system. Instead, they pump water from privately owned wells and bear only energy costs of \$0.11-0.22/cm. From 1987 to 1993, irrigated acreage expanded greatly due to an increase in groundwater licenses issued. Currently, more than 85% of Highland irrigation water comes from groundwater.

Highland industrial and domestic uses are also served primarily by groundwater. However, predictions are that demands from these sources will shortly exceed sustainable groundwater supplies (again assuming users pay only for extraction), even if agricultural demands were to cease completely. After recognizing this problem in 1993, water authorities stopped issuing new drilling licenses.

In the Jordan Valley, farmers receive water through a series of channels fed primarily by the Yarmouk River. Water is rationed. Delivery is regulated by "ditch riders" who open and close channels according to farmers' weekly water orders made to the Jordan Valley Authority. Limits on each farm's allocation are based on the type of crop. Unfortunately, 50-60% of the water flow is unaccounted due to broken meters and leaky channel gates. In other areas of the Jordan Valley, water is delivered through pressurized pipes where water is more tightly monitored. Again water is rationed.

In both systems in the Jordan Valley the price is negligible, i.e., less than $0.01, which is perhaps one fifth of the operating and maintenance cost. An increase to $0.04, which would at least cover a large proportion of the delivery costs, has been recommended. Agricultural water prices have begun to be increased recently, but the adjustments have been minor. In October, 1994, Jordan Valley farmers were notified of an increase in water prices to $0.011-$0.02/cm depending on the type of crop each farmer grows. Even this meager increase provoked a substantial adverse reaction. Farmers responded by going on strike and by not sending their children to school.

Because the Valley and the Highland are so poorly connected hydrologically, water projects involving the Jordan Valley with the nearby and accessible water resources of the Yarmouk and Israel offer more promising prospects for trans-boundary water cooperation than do domestic possibilities. Furthermore, because of the growing Highland shortage, prospects for improving Highland water availability may depend critically on enhancing water availability in the Valley through international cooperation and then augmenting the infrastructure to transport it to the Highland (e.g., via the Dayr Alla pumping station).

7. Current Water Situation in Judea and Samaria

Judea and Samaria obtain almost all of their water from wells and springs that tap into the three underground sub-aquifers of the overall Mountain Aquifer. Only about 7% of current water comes from surface runoff or purchases from Mekorot. Therefore, almost all possibilities for trans-boundary water sharing are tied to recharge, pumping costs, and use of the associated aquifers. A rudimentary market appears to operate for well water. The average price was $0.17 in 1990. Average consumption is 110-133 mcm/yr. Pumping rates, quantities, and period are determined and monitored by the Israeli Civil Administration.

Judea and Samaria are relatively undeveloped and, unlike Jordan and Israel, future water may be much more valuable than current prices suggest. Investment in drilling and irrigation technology could be quite valuable. However, this investment would lower, not raise, the value of water. Increases in demand are likely to be caused by increasing population and increasing income which may accompany investment.

8. Domestic Water Allocation and Potential for Reallocation[11]

Internal Water Reallocation. Given the wide variation in prices among users, the value of water forthcoming from new international projects and the potential for bargaining depends critically on its allocation. Because current water allocation at least in Israel and Jordan appears to be based at least in part on rational non-economic and non-efficiency objectives that influence price ratios among users, the value of marginal increments in water availability must be evaluated accordingly. Additionally, the potential for changing price ratios among users in response to new water availability or changes in other external factors must also be considered. One such external factor that could result in a change in price ratios is new prospects for peace. The importance of goals such as food self sufficiency and settlement of remote areas may be reduced by successful peace accords. If so, then partial equalization of water prices (across regions and sectors) may result. To set the stage for considering increments in water availability under such alternative scenarios, this section first considers the implications of partial price equalization at current water availability levels. Israel is used as an example.

Water pricing policies in Israel currently favor agriculture and industry by giving them

[11] Details on the economic analysis of domestic water allocation and pricing presented in this section can be found in Just, Netanyahu, and Horowitz (1994).

lower prices than household consumers. An increase in agricultural and/or industry prices will reallocate water to the household sector, which has a higher marginal value, and can raise total (unweighted) economic benefits from water. The cost to agriculture or industry depends on the price rise, total water availability, and demand elasticities in all three sectors. To demonstrate, assume that agriculture (A), industry (I), and households (H) have respective elasticities of demand of 0.5, 0.3, and 0.2 following Fisher (1994), and suppose that total water availability is 1750 mcm/yr which corresponds roughly to the pre-drought year 1990. Let sectoral price relationships be represented by $p_A = \gamma_A p_H$ and $p_I = \gamma_I p_H$ where p_j is the price in sector j and γ_j is the price ratio, a choice variable; j = A, I, H. The γ_j's may be regarded as indirect choice variables reflecting premiums placed on certain types of economic activity due to non-economic and non-efficiency objectives such as food security concerns, development regards for future generations, etc. If $\gamma_A = \gamma_I = 1$, then prices are fully equalized and sectors face identical prices. Current price ratios are approximately $\gamma_A = 0.50$ and $\gamma_I = 0.56$, which corresponds to prices $p_A = \$0.17$, $p_I = \$0.20$, and $p_H = \$0.34$ (see footnote 3).

Table 5 shows water use, prices, and sectoral benefits of water for different values of γ_A and γ_I where water supply is 1750 mcm/yr. Table 6 shows similar outcomes when water supply is increased to 1850 mcm/yr. Total benefits are unambiguously increasing as weights approach unity and, correspondingly, prices approach equality. Industry is helped by an increase in agriculture's price relative to households' price even when industry's price relative to households' price is unchanged.

Now consider an internal reallocation away from agriculture resulting from a 12% increase in agricultural water prices (which leaves agricultural prices 38% below average household prices). This adjustment could occur, for example, in response to successful experience with new peace accords if agricultural subsidies are motivated by interests in food and border security. The associated change in pricing parameters to $\gamma_A = 0.56$ and $\gamma_I = 0.56$ raises total benefits by 3.1% although agricultural benefits decline by 6.5%. By comparison, a minor reallocation from current prices to $\gamma_A = 0.5$ and $\gamma_I = 0.6$, which reduces some of the preference toward industry, raises aggregate benefits by a much smaller 0.16% over current benefits.

Complete equalization of agricultural and domestic prices keeping the industry break in place raises aggregate benefits by 9.4% while reducing agricultural benefits by 40.4%. Complete reallocation implied by equal prices across all sectors raises aggregate benefits by 11.7%. Thus, the subsidization of agricultural water is apparently responsible for most of the water use inefficiency. These results and similar exercises with parameters potentially reflecting Jordanian demands suggest that water conflicts in the Middle East are exacerbated by internal divisions of water that favor agriculture through low water prices.

Can New Water Change Old Coalitions? Now consider the possibility that new water availability may be able to weaken the political coalitions that lead to unequal pricing by reducing the sectoral costs of price equalization. Compare, for example, the results with initial price weights $\gamma_A = 0.50$ and $\gamma_I = 0.56$, and 1750 mcm/yr aggregate supply (Table 5), to the results with partial price equalization represented by weights $\gamma_A = 0.56$ and $\gamma_I = 0.56$, and the higher 1850 mcm/yr aggregate supply (Table 6) available after completion of the Yarmouk-Kinneret canals. In this comparison, the additional supply is allocated relatively more to domestic and industrial uses. Agriculture is less affected than when weights are adjusted without an increase in supply. Agricultural benefits decline by 4.7% ($401 million to $382 million) in this case compared to the 6.5% ($401 million to $375 million) decline when aggregate supply remains constant. Thus, the cost for agriculture to adjust weights is considerably reduced. This also permits a much larger aggregate benefits gain from the project, 7.2% ($639 million to $685 million) compared to 3.9% ($639 million to $664 million) when the weights are not adjusted along with the supply increase.

Table 5 also shows the change in total benefits from a change in aggregate supply computed by comparing the aggregate benefits in Tables 5 and 6. These figures reflect the marginal value of water for the country. The marginal value of water is higher the more equal are prices. This occurs because increments to water supply are assumed to be allocated among the sectors to maintain the given price weights, and more equal prices imply that higher value sectors implicitly receive more weight in water allocation.

An alternative to these allocation rules is to allocate increases in supply only to industry and households, e.g., the high value users. Consider the objective of raising benefits for industry and households subject to agricultural benefits not decreasing. Because industry and households face higher prices than agriculture, allocating 100 mcm/yr of new water to them (leaving agriculture's water unchanged) raises aggregate benefits more than allocating 100 mcm/yr among all three sectors according to a given weighting scheme. These results demonstrate how critically the value of a marginal increase in water depends on who gets the water.

Internal Reallocation Versus External Cooperation. The results in Tables 5 and 6 demonstrate that internal reallocation of water is more valuable to the Israeli economy than external cooperation over the Yarmouk-Kinneret canals, provided political parties can effect sufficient internal reallocation. Under current price weights ($\gamma_A = 0.50$, $\gamma_I = 0.56$), benefits are increased by 3.9% by the 100 mcm/yr additional water supply available to Israel from cooperation and completion of the canal project.[12] In contrast, even minor internal reallocation (changing the weights to $\gamma_A = 0.56$ and $\gamma_I = 0.56$) raises aggregate benefits by 3.1% holding aggregate supply constant at 1750 mcm/yr. A much larger 9.4% gain is possible by equating agricultural and domestic weights ($\gamma_A = 1.0$ and $\gamma_I = 0.56$) and an 11.7% gain is possible by equating all prices. These reallocations provides more to the Israeli economy than the additional water of the canal project. Again, one must bear in mind that these internal reallocations may not be appropriate in the context of other national objectives. If not, then international cooperation may offer the only rational alternative for easing water scarcity problems.

Interdependence with Current Peace Prospects. If, however, the agricultural water subsidy has a food security basis that will be eliminated with new peace agreements, then price equalizing adjustments may become feasible even if they have not been previously. Conversely, international cooperation on enhancing water supply may be important both for reducing internal political objections (the adverse welfare effect on agriculture is reduced) and for increasing confidence in peace and cooperation.

If lasting agreements on water cannot be reached, the ultimate success of peace is threatened. On the other hand, if lasting international water agreements can be found, then the long-term success of peace is more likely which, in turn, facilitates reduced security needs and more internal water efficiency. These considerations suggest that internal water price equalization, international water projects, and peace have synergistic effects that complement one another. Progress may not be possible on any of these three objectives individually but large gains may be possible when the three are taken together.

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[12] Compare the first entries of Tables 5 and Table 6. Benefit calculations at 1850 mcm/yr do not include costs of the Yarmouk project, but these one-time costs are small relative to the effects shown in Tables 5 and 6, which accrue yearly.

These considerations imply that political power of the agricultural sector should not be over emphasized as an explanation for current water pricing inefficiency. Strengthening the agricultural sector is not a declared government policy per se but is embedded in socio-political policies that have emerged in part from Zionist spirit and in part from national security considerations. Food security, settlement, and development of the Negev clearly are playing a major role in dictating the direction of planning and development in Israel.

Similarly, the norm of economic efficiency should not be overemphasized as a standard of comparison for water allocation schemes and mechanisms. Dominance of economic considerations by ideological, political, and nationalistic objectives clearly characterized the period from establishment of the state of Israel until at least the completion of the National Water Carrier in 1964. The years since then are characterized by an increasing conflict between economic and socio-political agenda. When pursuit of non-economic and non-efficiency objectives represent legitimate and rational public concerns, then economic efficiency may become an inappropriate goal. To the extent rational public concerns impose inequitable price ratios among users, international projects and the new water they produce must be valued accordingly. Similarly, the potential implications of new water and of other changes in external factors for price ratios imposed by rational public concerns must be evaluated as well.

9. Concluding Remarks

All of the countries in the Middle East face constraints to growth because of limited water supply, degradation and overexploitation of historic water resources, and population growth. International conflicts have hindered the adoption of potential solutions. External conflicts may also have exacerbated internal conflicts over water. Fragile diplomatic relations may have increased the desire for agricultural self-sufficiency, leading to subsidization of water to agriculture. Political rent seeking may have been more effective in these tense circumstances. However, it is not clear that political power models are necessary to explain current water pricing structures. Governments' water policies are often secondary to other socio-political goals. Considerations such as industrial growth, intra-sectoral equity, rationing, food security, settlement, and development of arid regions all have high priorities in national agendas.

Cooperation in water planning may allow reallocation of existing water resources or development of new resources that will benefit all parties. New resources can often be used more efficiently than existing resources because inefficient prior claims need not take precedence. More importantly, the presence of new resources may facilitate overcoming existing barriers to more efficient use of existing water resources because certain national objectives may be appeased thereby. Better use of existing resources can occur because the political and economic costs of changing existing water use patterns is reduced when supply is higher.

Several major international projects have been proposed that appear to offer significant efficiency gains. However, studies have typically failed to address the problem of how to facilitate needed cooperation. Demonstration of potential economic efficiency gains only implies that welfare could be improved if competitive solutions could be approximated. When such solutions involve lopsided sharing of the water forthcoming from particular international projects, international cooperation is not likely. Yet, because of terrain and transportation possibilities, such problems appear to result from most leading but yet undeveloped project proposals. This paper has demonstrated that standard bargaining considerations may cause obstacles to cooperation in spite of large potential efficiency gains. Further work in the context of bargaining is needed to identify provisions that will assure continued cooperation once costly initial investments are undertaken. Once all parties can be assured that promised future benefits are protected, more fruits from cooperative efforts can be expected.

Much of the debate about Middle East water is focused on projections of future demand. It is difficult in these debates to understand the potential for internal reallocation and to understand how reallocation opportunities affect the value of international projects. This paper has concentrated on analyzing these relationships. Results show that internal reallocation is potentially very effective in postponing scarcity problems. However, such solutions may not be politically feasible or may become feasible only with peace agreements and accumulated experience contributing to confidence in those agreements.

Once peace is achieved and international water projects become part of the regional development agenda, an increase in benefits is expected. With additional water supplies available to each country, the loss to specific sectors (especially to the agricultural sector) from price equalization will be lower than if water were simply reallocated with unchanged aggregate water availability. However, complete price equalization may continue to be inappropriate given other national concerns such as national security, land settlement, arid region development, tradition, and religion.

The empirical work in this paper is clearly highly tentative because (i) estimation of water supply and demand is at a primitive stage and (ii) because some of the physical hydrological relationships are not clear. Nevertheless, the results are sufficient to demonstrate that simple economic modeling of efficiency potential may be of little value in international negotiations. Water markets tend to allocate all incremental water to the country with highest marginal value and, hence, do not reflect the potential of international projects given political realities of international negotiations.

Table 1. Potential International Water Projects Affecting the Jordan-Yarmouk River Basin[a]

Project	Participants	Investment ($1,000,000's)	Quantity of Water (mcm/year)	Price of Water ($/cm)	Description
An international desalination project	Israel Jordan Palestinians	3,000-5,000	128	.88-1.20	Various plans with various desalination technologies are proposed. Independent desalination projects are also possible.
Building a 650 mcm pipeline to transfer water from the Euphrates	Jordan Iraq	2,000	120-160	.50 East Jordan 1.00 West Jordan	Transferring water is costly and complex.
Diverting Nile River water to Gaza and the Negev	Egypt Israel Gaza	136-347	91-149	.22-.247	Water to be supplied to Judea and Samaria instead of Gaza and the Negev by the National Water Carrier. Conveyance cost is reduced but Nile River water quality and ideological issues present problems.
Mukheiba Dam: A Jordanian dam on the Yarmouk (1960s)	Israel Jordan	552.4	180	.074-.131	Water would be supplied to Ghor Valley farmers, who currently pay less than one cent per cubic meter.
Maqarin Dam: A Jordanian-Syrian dam on the Yarmouk (1978)	Jordan Syria	1,031	275	.262-.455	Total capacity of 320 mcm. Syria gains 15 megawatts of electricity. The U.S. has offered financial support providing Israel's interests are considered.
Unity Dam: A Jordanian-Syrian dam on the Yarmouk (1987)	Jordan Syria	460.2	225	.34[b]	Half the size of the proposed Maqarin Dam. Syria would get all the electric power generated. Water (50 mcm) to be transported to Amman/Zarqa.
Storing Yarmouk River water in Lake Kinneret	Jordan Israel	27.6	100-240	.014-.022	Winter floodwater would be diverted by canal to Lake Kinneret and pumped to the Jordanian Ghor Valley in the summer months and to the Israeli National Water Carrier in the winter.
Litani-Hasbani Project	Lebanon Israel	10	100	0.088	Would also produce 70 million kilo Watts per year.

[a] All monetary values are given in 1990 U.S. dollars with prices deflated by the U.S. Consumer Price Index.
[b] Year of price is not known for certain but applies to years 1990 to 1993.
Sources: Kally, 1993; Lowi, 1993; *Statistical Abstract of the United States*, 1993; and World Bank 1994.

Table 2. Water Prices in Israel, 1990[a]

Domestic (Households)[b]	0.32 $~~0.58~~/cm for 0-8 cm
	0.75 $~~1.01~~/cm for 8-16 cm
	1.23 $~~1.49~~/cm for more than 16 cm
	$0.58/cm for outside water use (e.g., gardening)
Agriculture	$0.125/cm for the first 80% of quota
	$0.20/cm for the next 20% of quota
	$0.26/cm for water used above quota
Industry	$0.15/cm (average price paid) plus sewage charges

[a] Prices are given in 1990 dollars.

[b] Households must also pay a sewage fee of $0.32/cm.

Source: Tahal 1990.

Table 3. Recent Increases in Agricultural Water Prices in Israel[a]

Farm Use as a Share of Quota	1990	1991	1992
Substantially Below Quota	$0.125	$0.142	$0.167
Up to Quota	0.200	0.227	0.266
Over Quota	0.260	0.296	0.433
Substantially Over Quota			0.699

[a] Prices are given in 1990 dollars per cubic meter. "Substantially below quota" represents use less than 80% of quota in 1990 and 1991 and less than 50% of 1989 quota for 1992. "Up to quota" represents use between 80% and 100% of quota in 1990 and 1991 and use between 50% of 1989 quota and 100% of quota for 1992. "Over quota" represents use between 100% and 130% of quota for 1990 and 1991 and use between 100% and 110% of quota for 1992. "Substantially over quota" represents use above 110% of quota.

Source: Tahal, 1990; Government of Israel, various issues; IMF, 1993.

Table 4. Household and Industrial Water Prices, Jordan 1993[a]

Location	Water Quantities	Water & Sewage Prices
Amman	0 - 20 cm	$0.20/cm
	21 - 40 cm	$0.34/cm
	41 - 70 cm	$0.75/cm
	71 - 100 cm	$1.05/cm
	more than 100 cm	$1.27/cm
Jordan Valley	0 - 40 cm	$0.14/cm
	41 - 70 cm	$0.23/cm
	71 - 100 cm	$0.52/cm
	101 - 150 cm	$0.90/cm
	more than 150 cm	$1.27/cm
Rest of the country	0 - 20 cm	$0.14/cm
	21 - 40 cm	$0.19/cm
	41 - 70 cm	$0.60/cm
	71 - 100 cm	$1.05/cm
	more than 100 cm	$1.27/cm

[a] Prices are given in 1990 dollars and are for water plus sewage.

[b] Charges are based on a 3 month billing cycle.

Source: World Bank, 1993.

Table 5. Water Allocation with Sectoral Price Equalization, 1750 mcm Supply

	Sectoral Water Use	Sectoral Surplus from Water[b]	Average Price
$\gamma_A = 0.50$, $\gamma_I = 0.56$[a]	$q_A = 1160$	\$401	\$0.17
(Current Scenario)	$q_I = 111$	\$31	\$0.20
	$q_H = 478$	\$207	\$0.35
		\$639	MV[c] = \$0.25
$\gamma_A = 0.56$, $\gamma_I = 0.56$	$q_A = 1016$	\$375	\$0.18
	$q_I = 130$	\$34	\$0.18
	$q_H = 604$	\$249	\$0.33
		\$659	MV = \$0.26
$\gamma_A = 0.50$, $\gamma_I = 0.60$	$q_A = 1171$	\$403	\$0.17
	$q_I = 90$	\$27	\$0.21
	$q_H = 489$	\$210	\$0.34
		\$640	MV = \$0.26
$\gamma_A = 1.00$, $\gamma_I = 0.56$	$q_A = 411$	\$239	\$0.29
	$q_I = 199$	\$46	\$0.16
	$q_H = 1141$	\$414	\$0.29
		\$699	MV = \$0.28
$\gamma_A = 1.00$, $\gamma_I = 1.00$	$q_A = 431$	\$245	\$0.28
	$q_I = 31$	\$13	\$0.28
	$q_H = 1288$	\$457	\$0.28
		\$714	MV = \$0.28

[a] Household price receives weight 1. Household price = p_H, agricultural price = $\gamma_A p_H$, and industry price = $\gamma_I p_H$.

[b] Surplus is $S_i = \beta_j q_j^{1-\alpha j}/(1-\alpha_j)$ and q_j is market-clearing for price $\gamma_j p_H$.

[c] Marginal Value of Water = ΔTotal Surplus/ΔTotal Water Use where Total Surplus = $\Sigma_i S_i$.

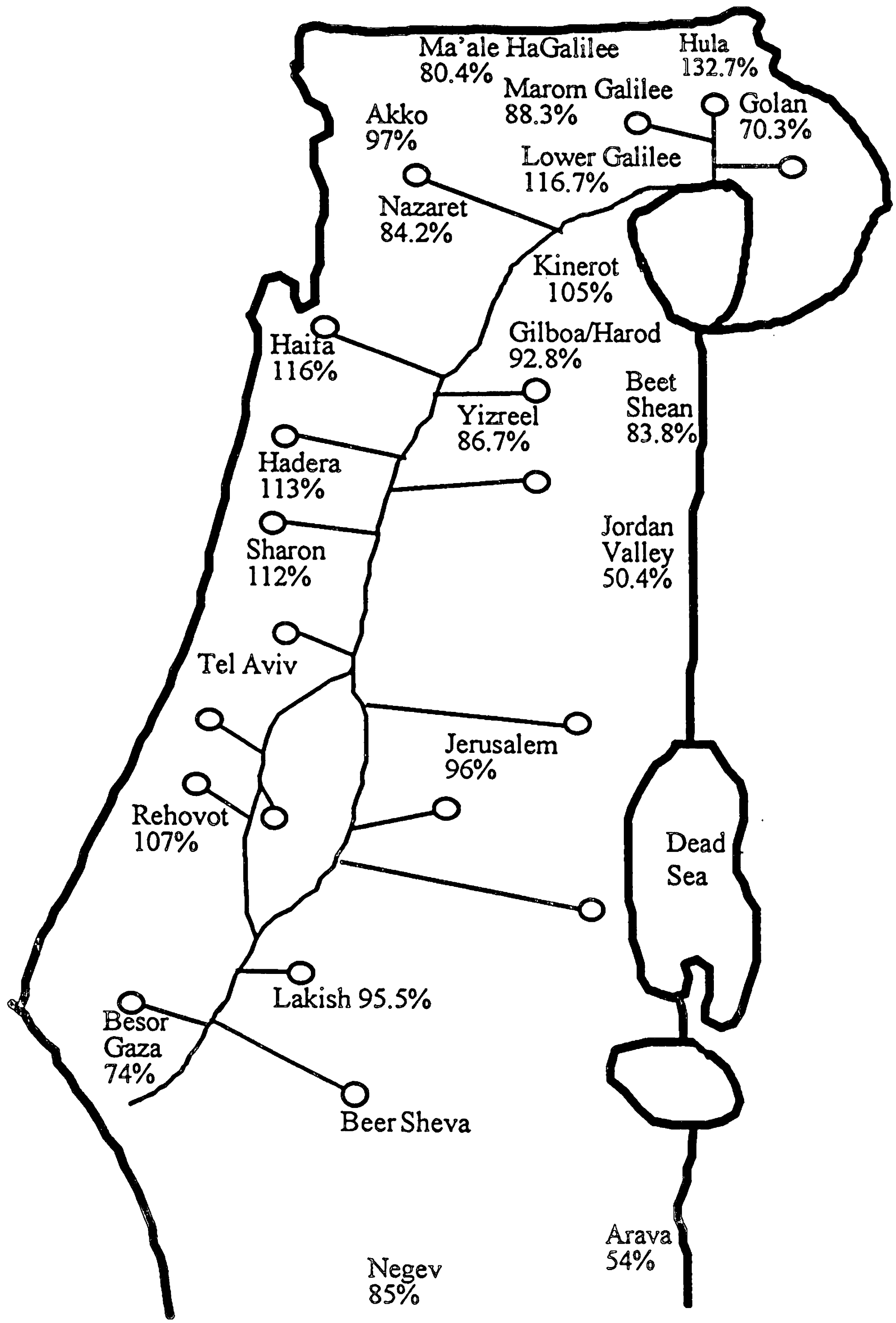
Table 6. Water Allocation with Sectoral Price Equalization, 1850 mcm Supply

	Sectoral Water Use	Sectoral Surplus from Water[b]	Average Price
$\gamma_A = 0.50$, $\gamma_I = 0.56$[a]	$q_A = 1205$	\$409	\$0.17
	$q_I = 119$	\$32	\$0.19
	$q_H = 526$	\$223	\$0.34
		\$664	
$\gamma_A = 0.56$, $\gamma_I = 0.56$	$q_A = 1052$	\$382	\$0.18
	$q_I = 138$	\$36	\$0.18
	$q_H = 660$	\$267	\$0.32
		\$685	
$\gamma_A = 0.50$, $\gamma_I = 0.60$	$q_A = 1216$	\$411	\$0.17
	$q_I = 96$	\$28	\$0.20
	$q_H = 538$	\$227	\$0.34
		\$666	
$\gamma_A = 1.00$, $\gamma_I = 0.56$	$q_A = 422$	\$242	\$0.29
	$q_I = 208$	\$48	\$0.16
	$q_H = 1220$	\$437	\$0.29
		\$727	
$\gamma_A = 1.00$, $\gamma_I = 1.00$	$q_A = 443$	\$248	\$0.28
	$q_I = 33$	\$13	\$0.28
	$q_H = 1375$	\$481	\$0.28
		\$742	

[a] Household price receives weight 1. If household price = p_h, then agricultural price = $\gamma_A p_H$ and industry price = $\gamma_I p_H$.

[b] Surplus is $S_i = \beta_j q_j^{1-\alpha j}/(1-\alpha_j)$ and q_j is market-clearing for price $\gamma_j p_H$. Surplus does not include costs of the project.

Figure 1. Regional Agricultural Water Use as Percent of Quota in Israel, 1990



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List of Tables

Table 1. Potential International Water Projects Affecting the Jordan-Yarmouk River Basin.

Table 2. Water Prices in Israel, 1990

Table 3. Recent Increases in Agricultural Water Prices in Israel

Table 4. Water Prices in Jordan, 1993

Table 5. Water Allocations When Sectoral Prices Are Partially Equalized, Supply = 1750 mcm

Table 6. Water Allocations When Sectoral Prices Are Partially Equalized, Supply = 1850 mcm

List of Figures

Figure 1. Regional Agricultural Water Use as Percent of Quota in Israel, 1990