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The Institute for Social and Economic Policy in the Middle East

Harvard Middle East Water Project

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AN ECONOMIC FRAMEWORK FOR WATER NEGOTIATION AND MANAGEMENT

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1. Introduction

Water and water rights are a matter of deep importance to all the parties to the Middle East peace negotiations. Indeed, the difficulty of agreeing on water issues is often cited as a likely stumbling block. Water involves national and social interests, as well as private ones, and contradictory positions on the property rights involved in water are strongly, even emotionally held.

This project proposes a mode of thinking about such issues that can assist to put them in perspective and thus assist their solution by negotiation. Precisely because of the complexity and importance of the issues involved, however, understanding of the project is best achieved through discussion that proceeds in stages, starting with matters that do *not* involve those issues and then introducing the issues one at a time. In reading this discussion, the following items must be borne in mind:

I. Although the proposal is based on economic analysis, and although the discussion begins with the analysis of the role of free market prices, it is *not* proposed to have a free market in water. For reasons detailed below, such a solution does not work.

II. Although the issue of property-rights (or historic claims) to water is introduced late in the discussion, this is done for reasons of analytic convenience. The property-rights issue is of paramount importance, and a principal aim of the project is that of assisting in the settlement of that problem.

III. Related to the previous point is the following one: As we shall see, it is not possible analytically to separate the various issues involved in a water

settlement. Indeed, it is important to do so. But such separation is a matter of analytic convenience, done in the interest of clear thinking. No satisfactory actual solution to the water problem can possibly be implemented unless all the issues are settled first. In particular, the analytic fact that (as we shall see) it is possible and useful to treat efficient water management and property rights as two separate problems certainly does not mean that an efficient management scheme can be implemented without agreement on property rights.

IV. As this suggests, the other principal aim of the project is to assist in the efficient regional management of water resources. That management (naturally assumed to be jointly done by the parties involved) will have to continue into the indefinite future. It will have to take into account the fact that water has social and national importance that transcends its private economic value.

2. The Economic Analysis of Resource Allocation

The central propositions of economic analysis concern the role of competitive prices in the allocation of scarce resources. Roughly put, in the simplest case of a manufactured, perishable good, prices guide a competitive economy to an efficient solution. Price above marginal cost indicates that consumers are willing to pay more for a good than the cost of producing additional units; hence more should be produced. Similarly, price below marginal cost indicates that consumers are not willing to pay for production of the last unit; hence less should be manufactured. If there are no social interests in the good that are not also private ones, the pursuit of private gain serves social ends.

The same is also true in the case of conservation of natural resources. Consider a mineral available only in finite supply whose rate of extraction is controlled by a social planner. If the planner were only to consider a short time period, then society's aims would be served by maximizing the difference between the benefits and costs associated with the mineral's extraction. But, of course, the entire problem of the conservation of such a mineral occurs because the planner must also consider the future. Such a planner must balance the net (benefits less costs) associated with present use against those obtained by reducing present use and preserving more of the mineral for extraction and use at some future date. This requires specifying a trade off between present and future net benefits. It is analytically convenient to do this by specifying a discount rate--the rate at which future benefits will be discounted to make them comparable to present net benefits. Once this is done, the discounted future net benefits can be added to the present ones and action taken to maximize the result. In general, the social interest in mineral extraction can be thought of as the maximization of the present value of the net benefit stream to be gained from the resource, with benefits, costs, and discount rate (the trade-off between present and future net benefits) evaluated from society's point of view.

Now consider the case of a mineral that is in private hands. Private owners will also have to balance the benefits and costs of extraction and consider the trade-offs among time periods.

From the private point of view, benefits consist of revenues and costs of expenditures so that private net benefits are simply profits. It is thus in the interests of private owners to maximize the present value of the profits to be earned from the mineral, making a calculation similar in form (but possibly not in substance) to that made by the social planner.

The point of this is as follows: *If all social benefits are reflected in what people are willing to pay for the mineral, if all social costs are reflected in the costs of extracting it, and if social and private discount rates coincide,* then again the pursuit of private gain will serve public interests. In particular, a perceived future shortage will produce the expectation that prices will be high in the future; this, in turn, will provide an incentive for mine owners to postpone extraction, thus alleviating the future shortage.

This result, however, only applies so long as the conditions italicized above hold. They do not do so in the case of water. We must therefore go on to more complex cases.

3. Negative Externalities: Efficiency and Property Rights

We first analyze the consequences of the fact that the social and private costs of water exploitation do not coincide. (The crucial fact that there are social or national interests in water that are not simply private interests is taken up later.) To do so, it is instructive to consider a specific, non-water example, that of the extraction of crude petroleum.

Crude oil is typically found in geological formations mixed with sand and with a natural gas cap above the oil. By far the most efficient and cheapest method of extraction (primary or flush production) is to drill one or more wells into the side of the formation and allow the pressure of the gas cap to drive the oil through the sands to the well. The benefits of flush production are destroyed, however, if someone drills on the gas cap allowing the gas to escape. They are also destroyed if the rate of extraction of the oil is too high, allowing the gas to pass through the oil and disappear.

In the United States, the land above an oil field is typically owned by many different landowners. The question naturally arises as to who owns the oil beneath the land. In the early history of the U.S. petroleum industry, that question was decided by the courts in terms of the "Rule of Capture" which stated that the oil belonged to the one who brought it to the surface.

This rule created what economists call a "negative externality". It gave every landowner an incentive to drill his or her own well and an incentive to extract the oil as fast as possible. As a result, the social cost (the effect on all the landowners together) of drilling on the gas cap or of extracting the oil too quickly was not reflected in the private costs of the individual landowner. Before further regulation was imposed, several large oil fields were literally ruined.

Regulation is only one solution to this problem, however, and not the best one. A different

solution would be to repeal, in effect, the Rule of Capture, and operate as follows. The right to exploit the oil in a given field would be given to a corporation owned by the landowners. That corporation would operate the field as a unitized whole, competing with many other such fields. Because the negative externality would no longer exist, the difference between private and social costs would be erased and the pursuit of private gain would again serve public ends.

It is important to realize that this result holds regardless of how the shares of the corporation are divided among the landowners. That question--the original question as to property rights--would have to be settled for the solution to be implemented. But it is a question analytically independent of that of efficient extraction.[1]

Note also that the property-rights question has now become one of money. A share of the unitized corporation is a claim on that corporation's future earnings. The value of such a claim can be estimated.

4. Efficient Joint Management of Water Resources: the Base Case

The water problem in the Middle East has some of the aspects of the crude petroleum example just discussed. (It also involves the very important additional problem of national and social benefits from water. This is considered below.)

Water is a resource shared among countries, in particular, among Jordan, Palestine,[2] and Israel[3]. Water extracted and used by one country is not available to be used by the others. Further, certain methods or rates of water extraction can lead to the depletion of the resource in an inefficient manner.

In this circumstance, it is natural to think of the efficient management of the region's water as unitized. In other words, efficient management requires international cooperation. We envisage a joint water management authority managing the resource for the benefit of its owners--the peoples of the three countries. As in the petroleum case, the question of property rights--of who owns how much water--must be settled before such a joint authority can operate, but, also as in that case, one can think about such operation separately from thinking

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1 The proposition that this is generally true is due to Ronald Coase. It was one of the achievements for which he received the Nobel Prize in economics in 1991.

2 We refer to the emerging Palestinian entity as "Palestine" without prejudging the ultimate outcome of the peace negotiations.

3 In fact, the water systems of Syria and Lebanon are also involved. For simplicity's sake, we shall limit the discussion to Jordan, Palestine and Israel, and the initial version of the model deals with only those countries in detail. Expansion to include Syria and Lebanon can be accomplished at a later stage.

about the property-rights question. Moreover, as we shall see, doing this will assist in the solution of the property-rights dispute.

It will be instructive to consider the operation of such an authority without yet introducing the issues involved in national water interests and policy. This will provide a base case into which such issues can in fact be introduced. The construction of this base case is the first empirical task of the project.

Divide the region into districts. Each district must be small enough that it is a reasonable approximation to think of water as being supplied and used in a single location. For each district, the marginal cost of water extracted there is estimated. Of course, different water sources within the same district may have different costs; this leads to a supply curve for district water.[4]

Next, the demand curve for water used in each district is estimated, and this is done for each of several dates extending thirty or forty years into the future. That estimation is done as follows: First, population estimates and projections of domestic water consumption per capita are obtained; second, industrial demand for water is simply projected as independent of price; third, agricultural demand curves are estimated as described below. Both domestic and industrial use are assumed to be relatively price insensitive; possible price sensitivity can be dealt with in terms of sensitivity analysis when the model is run.

Agricultural demand, however, certainly is price sensitive. The elasticity of such demand is to be built up by considering the water requirements of each crop per unit of output and then estimating which crops (and which irrigation technologies) will be profitable at different prices of water. The resulting elasticity is then used to construct an agricultural demand curve for each district calibrated to the actual or projected cropping patterns at the current price of water.[5]

The remaining data requirement is that of the cost required to transport water between districts. That transport will have to be one of three types. The first is the natural flow of rivers, costing nothing. The second is the use of the Israeli National Water Carrier or other transport systems for which data already exist. The third involves the construction of

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4 Of course, such supply curves may be related across districts; one cannot use the same water in two places at once.

5 In principle, there is no need to assume constant-elasticity demand curves. In practice, however, some such simplifying assumption will probably be necessary, at least at the outset. Both for agriculture and industry, demand estimates will be constructed paying attention to water quality.

potential new transport systems[6].

Given this information, one can then determine the efficient prices for water in each district for each of several years in the future. Those prices are determined by two conditions: First, the difference in price between any two districts must equal the cost of transportation between them; second, water demand in each district must equal water supply, including in supply the net imports into the district from elsewhere.

Among the results of such a model will be the following:

1. The benefits of investment by the joint authority in desalination plants, imports, or other capital projects, can be assessed in terms of profitability.

2. By valuing water, the property-rights dispute can be monetized. The negotiators will be able to think in terms of the money value of the property rights involved which will quantify the negotiations.

The latter point is one of great importance, *particularly because* (as later explained) *it is already clear that the amount of money involved cannot be very large.* Before discussing this point, however, it is necessary to go on to a consideration of social benefits from water that are not private benefits--to a consideration of national water policies.

5. National Water Policies and National Demand Curves

The base-case framework described above is not sufficient. It ignores the fact that there are social benefits to water that are not simply private benefits. For example, whether commitment to agriculture is important for ideological reasons or for reasons of social stability, the countries of the Middle East are likely to take an interest in agriculture beyond its profitability. More generally, historical, ideological, and even emotional attitudes towards water reflect the fact that the societies involved do not regard the benefits from water as being totally reflected in its profitable economic use.

The fact that social and private benefits differ matters a great deal. In particular, it appears plain that any attempt to create a free market in water or to promote trade in water at the efficiency prices described above will surely fail. Palestinians, for instance, express the fear that Israelis, with their richer economy, would end up purchasing too much water. That fear legitimately reflects the proposition that there are social benefits to the use of water in Palestine that are not private ones. (Otherwise there would be no reason to object to a trade in which Palestinian water sellers willingly trade water for money, thereby demonstrating that they would rather have the cash than the water.)

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[6] As discussed below, the output of the project will be useful for capital projects such as the design and construction of such systems.

Similarly, Israelis may fear that an expanding urban population in Palestine might purchase water at a higher price than Israeli farmers could afford. That fear also reflects the view that there are social benefits to water that are not reflected in the private profit-and-loss calculus.

The model described above can be adapted to incorporate such issues and thus to resolve them. To do this requires the expression of national policies (in consultation with policy-makers) as additional demand curves for water. Such curves would show (possibly by location) how much each society would be willing to pay for water at different water prices above and beyond the private demands described earlier.

There are several important points to understand about this procedure.

I. It is not true that water is literally "beyond price".

a. In the first place, at a high enough price for water it would be cheaper to pension off the farmers or retrain them for employment in industry or commerce. More generally, there are national goals other than water. Expending more and more on water will make those goals less attainable. Water is not worth an infinite amount.

b. Secondly, even if one does not agree with this, a national-policy demand curve can be constructed; that demand curve will simply be vertical.

c. In fact, water cannot be worth more than the cost of reproducing it. At the outside, the water that naturally occurs in a country cannot be worth more than the cost of desalinating enough seawater to replace it and transporting the desalinated water to the appropriate locations.

2. *The construction of a national-policy demand curve is analytically independent of the resolution of the property-rights question.* An owner of water who refuses to sell at a given price is in fact demanding it at that price. This is because, by refusing to sell, the owner is incurring an opportunity cost; he or she is giving up the money that could be made by the sale. Since the same analysis applies to refusals to sell by nations, national-policy demand curves can be constructed without knowing the solution to the property-rights problem.

With social and national goals incorporated, the model described in the preceding section can be run to obtain efficiency prices. At *these* prices, the nations of the region will be willing to buy and (especially) sell water to each other, since they have (in effect) named the prices themselves by specifying their national-policy demand curves. One can then envisage a joint management authority operating to effect such sales and purchases and making investments as before.

Constructing the details of how such a joint authority would function is an important relatively longer-term goal of the project. The short-run goals, however, involve materially

assisting the negotiations.

6. Assisting Negotiations: Property Rights

The first way in which the negotiations can be assisted has already been suggested. The output of the model will put a value on water. Dispute over property rights thus becomes a dispute over monetary values. (Recall that all national aims towards water have already been incorporated.) This is likely to assist the negotiations by changing their focus to a negotiation over money. That will be particularly successful if the money involved turns out to be relatively small.

In fact, we already know that this is the case. As observed above, water cannot be worth more than the cost of replacing it through desalination. Such costs are known. They suggest an outside limit of a present value (capital sum) of from five to ten billion dollars on all the water in dispute.[7]

Further, that value is much too high. One reason for this is that the figure given ignores the fact that the naturally occurring water to be replaced also has extraction and transportation costs, ranging from 20 to over 40 cents per cubic meter. Those costs must be subtracted in calculating the value of the water. A second reason is that desalination is not the cheapest method of water replacement; certain import projects are likely to be cheaper. Third, a very preliminary run of the base-case model suggests efficiency prices for water considerably below the cost of desalination.

Moreover, the figure given is the value of *all* the water in dispute. But no one supposes that the property-rights question can be solved by giving one or another of the participants all the disputed water. Rather, different proposals for water sharing will be (and have been) set forth. What must be valued is the difference between proposals. Since that difference will certainly be much less than the difference between giving all the water to one party and giving it to another, the value of what has to be negotiated will also be far less. Preliminary estimates suggest that what is involved may well be less than a capital sum of two billion dollars--possibly considerably less. These are sums over which nations can negotiate.

7. Assisting Negotiations: National Policies

There are additional aids to negotiation as well. The imposition of national policies towards

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[7] Roughly, there are 600 million cubic meters of water in dispute. The cost of replacement through desalination of seawater is not greater than one dollar per cubic meter. Hence, the annual cost of replacing all the water in dispute is not greater than roughly $600 million. At any reasonable interest rate, the present value of the costs of such replacement in perpetuity is less than ten billion dollars, and probably considerably less.

water imposes costs and supplies benefits. In particular, subsidization of agriculture or any positive national-policy demand for water raises the efficiency prices for water. Users of water will have costs: those who own the water will have gains.

By running the model with and without national-policy demand curves and with different combinations of those curves, one will be able to assess the costs and benefits of national policies. This involves both the costs to the country whose policy is being analyzed and the costs or benefits to other countries. By doing this it will be possible to monetize negotiations over water policies themselves. This is of interest for longer-run settlement of water issues and for joint management.

Obviously, the distribution of the benefits depends on the solution to the property-rights question, so the two issues are interrelated. Various runs of the model can illuminate what is involved.

8. Beyond the Negotiations: Water Management

As already suggested, the proposed project will have benefits even beyond assisting the negotiations. The proposed model, continually updated, will assist in the joint management of the region's water. In particular, the project can assist in the establishment of criteria for the choice of just which joint water resources should be jointly managed. It will explain how prices and quantitites of the jointly managed resources will be determined, and it can guide a joint authority as to which investment projects to undertake.

While the exact rules for such investment projects must be worked out, some general principles are clear. Investment projects should be undertaken if and only if they are profitable in terms of the efficiency prices produced by the model (efficiency prices which already include national goals as to water). Such profitable projects will have benefits accruing differentially in different locations and thus differentially to different countries. How those benefits accrue will depend on the solution to the property-rights issue, but, given that solution, the model will generate the geographical distribution of benefits. This can suggest the proportions in which the capital required for the projects should be raised.

Among the projects that a joint management authority will have to consider are those involving importation of water from outside the immediate region (from Lebanon or Turkey, for example). The evaluation of any such project must involve the costs of transportation involved and the price to be paid for the water. The model here envisaged will assist in such an evaluation in an important way. Specifically, it will enable the joint management authority to calculate the price at which it should be willing to import water *taking into account the value of water in the region as implied by the national policy demand curves.*
This tool can also be used to indicate where in the region the imports would be of most value.

As this suggests, the system of water management here envisaged is one of managed

international trade in water. This is true not merely as regards imports; it is also true as regards the joint resources of Jordan, Israel, and Palestine. The joint authority would develop and operate those joint resources and supervise trade among the three countries at the (national-policy-included) efficiency prices. Those prices (and negotiations over policies) will assist the three countries in the explicit consideration of the costs of their water policies and will thus promote efficient water usage inside their own territories.

This process will be an ongoing one. As economies and populations change, private demand curves will have to be updated. As a result, national policies will have to be reconsidered, reevaluated, and renegotiated with the other countries involved. By providing a framework for doing this, the model proposed and the joint management arrangements contemplated can assist in promoting ongoing cooperation rather than continued conflict.

Such cooperation must first be achieved in the current water negotiations, however. By monetizing the issues involved and showing how to think systematically about the benefits and costs of different arrangements of property rights and water policies, the proposed analysis can remove much of the natural emotion from those negotiations and assist in achieving a successful outcome.

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