SUSTAINABILITY, EFFICIENT MANAGEMENT, AND CONFLICT RESOLUTION IN WATER

by Franklin M. Fisher and Annette T. Huber-Lee

Water is often considered to be the area in which major crises will arise in the coming years. Such crises are expected to take the form of serious water shortages in different parts of the globe. Further, disputes over water ownership, whether between nations or competing water-use sectors within a nation, are commonly expected to be a major source of conflict.

It is important to realize that one cannot generally analyze such issues in terms of global water supplies and demands. Water shortages are intrinsically local or regional in nature. A shortage in Africa, for example, is not easily offset by a surplus in Australia. Hence, while inter-country transfers of water, along with trade in virtual water (the water embodied in food and other products), are potentially important, analysis of water problems must proceed by looking at particular areas rather than by global supply and demand analyses.

Coping with future water crises will require the implementation of efficient, sustainable water management. It will also require ways of resolving water disputes, and, as we shall see, this is best done through methods that involve thinking about water in terms of its value rather than in terms of its quantities and ownership. Fortunately, tools now exist for the achievement of both these tasks. These tools, discussed below, are the Water Allocation System (WAS), and its more powerful successor, Multi-Year Water Allocation System (MYWAS); they permit the user to take account of the special nature of water by imposing water policies that reflect social values that are not private values (such as using water for environmental purposes or subsidizing water for farmers). Hence, while these tools are economics-based, they are not economic in a narrow sense.

The WAS tool was first developed in the 1990’s by the Water Economics Project—a joint venture of Israeli, Jordanian, Palestinian, American, and Dutch experts generously facilitated by the government of The Netherlands.\(^1\) With similarly generous support from the Czech Development Agency, the Palestinian Water Management Authority, and the World Bank, the tool has been used in a number of countries, including Israel, Jordan, the West Bank, and the Gaza Strip.

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\(^1\) For more information on the Water Economics Project, see the website: [http://www.water economicsproject.org](http://www.water economicsproject.org)
Authority is now far along in development and use of its own MYWAS model (described below). Further, there is a commitment to proceed with MYWAS in Jordan, as well as strong interest in Lebanon and Israel. This paper explains the utility of the MYWAS model in resolving water disputes, with results from Israel, Jordan, and Palestine. It shows the importance of rational thinking about water. The idea that the next war will be about water is a myth, provided that the disputants think about the matter rationally.

**THINKING ABOUT WATER**

Water is an economic good with special attributes. Those attributes include an ability to create social benefits that are not enjoyed by private actors only. Two prominent examples of such social benefits from water are agriculture and environment. That societies elect to subsidize water for agriculture shows that water used for agriculture has a higher value to society as a whole than it does merely for the farmers involved.

Despite these special attributes and the fact that water is essential for human life, it is possible to give water a monetary value. In particular, since water cannot rationally be valued above the cost of replacing it, for any country with a seacoast (or who cooperates with neighbors that do), the cost of seawater desalination puts an upper bound on the value of water that can be surprisingly low.

The following example involving the coast of Israel and Palestine (first put forward in 1990 by the late Gideon Fishelson of Tel Aviv University) shows how water can be monetized. It led to our project.

The cost of desalination on the Mediterranean coast of Israel and Palestine is not more than roughly US $0.60 per cubic meter, including capital costs. Hence, water in Tel Aviv or Gaza is not worth more than $0.60 per cubic meter. With proper planning, were an alternative to this desalinated water to cost more than $0.60 per cubic meter, it would be inefficient to use it. A large amount of the water in dispute between Israel and Palestine, is not on the coast but instead lies underground in the so-called “Mountain Aquifer.” It costs roughly $0.40 per cubic meter to extract and convey water from the aquifer to the cities of the coast. This establishes the value of ownership of Mountain Aquifer water at not more than $0.20 per cubic meter, ($0.60 at the place where it is used - $0.40 to get it there). Hence, even though 100 million cubic meters (MCM) per year of Mountain Aquifer water is a large amount in the context of the Israeli-Palestinian dispute, it cannot be worth more than $20 million per year (100 MCM x $0.20 per cubic meter). This is a small sum among countries—smaller, of course, to Israel than to Palestine—and does not come close to the cost of one fighter plane.

The wider lesson of Fishelson’s example, however, is that water is not beyond price, and that thinking about the value of water rather than directly about its quantity can lead to results that may bypass the usual apparent stalemates.

Note also that the desalination upper bound is just that – an upper bound. It should not be thought that the efficient answer to water issues is always, or even
generally, desalination. In fact, the results obtained by running our models without desalination plants imply that desalination on the Mediterranean coast of Israel and Palestine is currently not an efficient technology except in times of major drought.

**WHY ACTUAL WATER MARKETS WILL NOT WORK**

It is often true (and important) that free, competitive markets can be relied on to provide an efficient and, in some ways, optimal allocation of resources. However, for this to hold, the markets must really be competitive, consisting of very small buyers and sellers who cannot individually affect the price. Further, all social costs and benefits must consist of private costs and benefits so that they are reflected in the functioning of the private market. These conditions are often not satisfied when it comes to water markets. Water markets are generally not competitive, and water in certain uses can have a social value that exceeds its private value.

This latter phenomenon applies to environmental effects of water, and can also apply where water is subsidized, as is frequently done for agriculture. Such a subsidy for agriculture reveals that water in the hands of farmers is valued by society more highly than by the farmers themselves.

Even when the private market will not work, however, economic analysis can still play a role in water management and agreements. The use of the WAS and MYWAS models permit the user to impose its own water policies and values, with the model then showing how to optimize the net benefits to be received from water, optimizing the allocation of water in a way that free markets cannot. While the models do not determine public water policies, they assist the actual policy makers.

**OPTIMAL SUSTAINABLE MANAGEMENT**

We now illustrate how the MYWAS model can assist with the efficient and sustainable management of water. Though our example focuses on the Middle East, these illustrations and applications are by no means confined to that region. As Fishelson's example shows, rational thinking about water requires focusing on the monetary value of water rather than just its quantity. The MYWAS model is based on this view.

In the model, the region or country studied—whether it is the Middle East, Brazil, China, India, or the US—is divided into districts. The water sources within each district are specified, along with the cost of extraction and the sustainable yield. Further, demand properties are specified for different user types (e.g., households, agriculture, and industry). Those properties are not simply the amount of consumption “required;” they consist of demand curves showing the quantity of water that would be demanded at different prices. Water may be essential for life, but that does not make water demand totally insensitive to price, particularly once basic needs are covered. Information on water infrastructure is also required (treatment plants, desalination plants, storage facilities, and conveyance lines).

Finally, as suggested above, the user imposes constraints on the model that
reflect his or her views of social values for water. For example, the user can specify an amount of water to be set aside in a district for environmental purposes. The prices at which water is to be sold to farmers or given to the needy can also be set if desired.

MYWAS takes these inputs and calculates the water flows that will maximize the present value of the system-wide net benefits received from the available water. These consist of the gross benefits (measured by the areas under the different demand curves) less the costs. It should be noted that “efficient water management” does not only mean purely technical efficiency; it also means benefit-maximizing allocation of water flows.

It is very important to note that the data as to supply, demand, and especially infrastructure can either be for an actual period, or for projections for later periods. This latter use provides powerful guidance as to the benefits to be had from contemplated infrastructure projects, a very important application of the model.

MYWAS has numerous capabilities:

1. The first is determining the timing, order, and capacity of infrastructure projects. In this context, the user specifies a menu of possible infrastructure projects, costs and benefits, and the model then gives the best infrastructure plan, showing which projects should be built, to what capacity, and at what time.

2. Another application is storage management, which determines the use of water reservoirs.

3. The third is aquifer management. Aquifers can be pumped at rates above their average annual renewable flow in times of drought and recharged in better times. Given predictions as to rainfall, MYWAS shows the optimal pattern in which to do this.

4. But, of course, the future rainfall pattern cannot be known with certainty. MYWAS provides a systematic study of the uncertainty of climate variables.

5. The multi-year aspect of MYWAS also allows users to study the effects of ‘global warming’ scenarios.

6. Finally, MYWAS aids in determining the best rate of pumping of a fossil aquifer.

**Shadow Values and Scarcity Rents**

MYWAS also produces a system of shadow values. Shadow values show what increasing the amount of additional water would be worth at different locations and times, as well as how it should be valued for planning purposes—even though the user can specify other values to be used as actual prices.

Such shadow values play the same role when there are social benefits and costs that are not private, as do competitive market prices when all benefits and costs are private. Indeed, where there are no public benefits or costs other than private ones, the shadow values of water would be the prices at which demand and supply curves intersect. Further, where there are non-private social benefits costs, and the government directly or indirectly specifies the prices at which users can buy water,
than the government can be thought of as buying water from the producing system at shadow values and selling it to the private users at the specified prices. In that case, the shadow values are the “prices” at which water supply curves and the governmental demand curve intersect.

The shadow value of water at its source is called the “scarcity rent,” and reflects the demand and supply for that source. In effect, it is the system-wide value of water at the source. The scarcity rent of a particular water source is not the cost of extraction, treatment, and conveyance. Rather, the scarcity rent is the pure value of the water itself as opposed to the cost of the facilities used to provide it. Indeed, when there are adequate extraction, treatment, and conveyance facilities, the shadow value of water from that source in the place where it is used is equal to the scarcity rent at the source less the direct costs of getting it there. We have already seen this in Fishelson’s example, where the value at the coast ($0.60 per cubic meter) less the conveyance and extraction cost ($0.40 per cubic meter) equaled the ownership value of the water in situ ($0.20 per cubic meter) – the scarcity rent.

If water is to be efficiently conveyed from point A to point B over a conveyance line whose capacity is more than adequate, then the shadow value at B must equal the shadow value at A plus the operating cost of conveyance per cubic meter. It follows that, in contemplating whether to construct such a conveyance line, one will gather information by running the WAS or MYWAS model without the line and seeing whether the resulting shadow value at B exceeds that at A by more than the per-cubic-meter operating cost of conveyance would be, were the line constructed. If that condition is not satisfied, then the conveyance line should not be built, as it will not be used. If the condition is satisfied, then the model should be used to perform a full benefit cost analysis of the conveyance project.

If a new source of water is to be developed, then the shadow value of water in the district where the source be located (calculated by running the model in the absence of the project) should be compared with the cost per cubic meter of using the new source. Only if that cost is less than the relevant shadow value will developing the source be efficient.

**CONFLICT RESOLUTION AND MUTUALLY BENEFICIAL COOPERATION**

MYWAS can also be used to resolve a broad range of water conflicts and to guide mutually beneficial cooperation.

First, by using its own MYWAS model, each party in a dispute can assess the effects that a proposed agreement will have on itself. This should help in facilitating cooperation. Moreover, with the use of these tools, the dispute can be reduced to monetary terms after accounting for the special values and social benefits of water. Negotiations over money should be less emotional hence easier than negotiation over water quantities.

Beyond this, however, MYWAS can be used to guide mutually beneficial cooperation in water. In such cooperation, the parties would trade in short-run permits to use each other’s water. Those trades would take place at the shadow values
generated by MYWAS for the affected districts and thus prevent monopolistic elements from entering. Those prices would change with changing conditions such as drought or population growth. Because such trades would be purely voluntary, both buyer and seller would gain.

We illustrate this both for the case of bilateral Israeli-Palestinian cooperation and for the case of trilateral Israel-Jordan-Palestine cooperation predicted for 2020. While the fact that every participant gains (or at least cannot lose) from MYWAS-guided cooperation is a completely general property, and the lessons of the qualitative results seem very likely to hold, it is important to recognize that these predictions were made at the end of the 1990’s and thus the quantitative results should be taken only as illustrative.

![Figure 1: Partial Map of Regional Water Supplies and Systems in Israel, Jordan, and Palestine](image)

The two regional sources of water on which we concentrate are the Jordan River and the Mountain Aquifer (See Figure 1.) The two sources are roughly equal in size, and each yields about 550-650 cubic meters per year. The Jordan River is claimed by Israel, Jordan, and Palestine. The Aquifer is claimed by Israel and Palestine. Cooperation gains are a function of water ownership; the results given are based on varying assumptions of ownership. These assumptions are not intended as political
in any way.

For the Jordan River, we use three possible assumptions as to percentage of water ownership:

A. Israel 92%, Jordan 8%; Palestine 0. (This is approximately the existing situation.)
B. Israel 66%; Jordan 17%; Palestine 17%.
C. 33.3%; Jordan 33.3%; Palestine 33.3%

For the Mountain Aquifer, we examine ownership cases varying from (case I) Israeli ownership of 80% and Palestinian ownership of 20% (roughly the present situation) to (case IV) Israeli ownership of 20% and Palestinian ownership of 80% by shifts of 20% at a time.

Israel-Palestine Bilateral Cooperation
Figure 2 shows the gains from bilateral Israel-Palestine cooperation in 2020 as a function of the different ownership assumptions. Note that Figure 2 has four panels (as does Figure 3, below), each panel corresponding to a different assumption concerning ownership of the Mountain Aquifer. Within each panel, the three cases of the assumed ownership of the Jordan River are exhibited. (In effect, the panels are all different slices of a three-dimensional diagram.) The heights of the various columns show the gains from cooperation.

Look first at Figure 2(I) – the case of an 80-20 Israeli-Palestinian division of the Mountain Aquifer. As we should expect, in Case A of Jordan River ownership where Israel has most of the river and Palestine has none, Palestine benefits most from cooperation—far more than does relatively water-rich Israel. Further, the same is true for the other cases of Jordan River ownership. But an interesting phenomenon appears. As expected, Palestine gains more from cooperation in Case A in which it owns no Jordan River water than it does in Case B, in which it owns 17% of the river. When we move to Case C, however, where Palestine has 34% of the river, the gains to Palestine once again increase, being slightly higher ($206 million dollars per year) than in Case A ($197 million dollars per year), even though Palestine has considerably more water in case C than in Case A.

The reason for this is not hard to identify. Palestine has considerably more water in Case C than in Case A, but Israel has considerably less. Both buyer and seller gain from WAS-guided cooperation, and, in Case C, Palestine gains by selling water to Israel, despite its low share of the Mountain Aquifer. Correspondingly, Israel, whose gains as a seller decrease slightly from Case A to Case B has increased gains as a buyer in Case C.

This phenomenon becomes even more pronounced in the other panels of Figure 2, in which Palestine has increased shares of the Mountain Aquifer. In each of those panels, Palestinian’s gain from cooperation increases as it owns more and more Jordan River water; that is because it gains as a seller. Correspondingly, Israel gains as a buyer.
Gains from Trilateral Cooperation
Israel, Jordan, and Palestine, 2020

Figure 3
Table 1. Gains for all coalitions, 2020 (millions of 1995 dollars)

Figure 3 shows the gains in 2020 when Israel, Jordan, and Palestine all cooperate. Table 1 displays gains in that year for every possible case of bilateral cooperation between two of the three parties. The following phenomena are of interest.

First, all three parties typically gain from cooperation (and, as before, depending on ownership arrangements, the gain for each party can be either as a buyer or a seller). Second, when Israel owns most of the water, it gains more from cooperating with both Jordan and Palestine together than it does from cooperation only with Palestine. Correspondingly, both Jordan and Palestine gain less from trilateral cooperation than from bilateral cooperation with Israel. That is because, in such cases, both Palestine and Jordan are buyers so that the demand for sales from Israel is greater than in the corresponding bilateral cases, and the sales price is correspondingly higher. But this phenomenon does not always appear when other ownership cases are examined.

Further, it is always the case that the total gains to two of the parties of admitting the third into their cooperative arrangements are always positive, so that, with side payments, all three parties can benefit from such admission.
Gains from Cooperation vs. Gains from Ownership Shifts under Cooperation

The most important conclusion from these cases is that WAS/MYWAS guided cooperation in water would benefit all parties—Israeli and Palestine the most. Indeed, the gains from such cooperation generally exceed those that would be obtained from moderately large ownership shifts. This is particularly true under cooperation.

Indeed, one value of WAS/MYWAS-guided cooperation is that it reduces the value of ownership shifts, making them easier to negotiate. Furthermore, the gains from WAS/MYWAS-guided cooperation would be greater in other ways than are shown above. In particular, as populations and other factors change, a quantity agreement that is adequate when signed can easily become out of date and a source of new tension. WAS-guided cooperation provides a flexible means of readjusting water usage in a way that all parties benefit.

Our results demonstrate that Israel and Palestine would both benefit from a sewage treatment plant in Gaza. Further, the treated effluent would be sold to Israel to use in agriculture in the Negev. With this, Israel would have a positive economic incentive to assist in the construction of the plant, which would be a confidence building mechanism that would not interfere with the core values of either party.

Possible Objections

Of course, there are possible objections to such a plan, however. Some of those are without merit, but others deserve careful consideration. We begin with the less meritorious ones.

Forced Sales

Throughout the history of the Water Economics Project, some have raised the objections, “You are going to force us to sell our water,” or “Why should we give water to our neighbors?” (Indeed, an Israeli water expert – who should certainly know better - has repeatedly publicly voiced the latter objection.) These questions are not objections, but rather misunderstandings.

First, because there are a finite number of countries involved and no outside trades in this situation, it is impossible for all of them to be net sellers. Even more important, WAS/MYWAS guided permit sales are never “forced,” and the selling country sells only when it is in its own advantage. Because of this, both parties would gain from the trade.

“The Richest Country Will Buy all the Water”

Another issue is the concern that the richest country will buy all the water, or that the disparity in economics makes water-permit trading either impossible or unfair. This argument is not valid, particularly because we are not considering trade
between individuals but between governments. Poor countries only sell when it benefits them as they gain from the sale. Further, as they sell more water, the remaining water becomes more valuable to them, and they will eventually stop selling.

The other reason is the mirror image of this. The rich country may have a lot of money, but why should it want to buy all the water in sight? Water is valuable when it is scarce and needed for essential uses (drinking, for example). But it becomes less valuable as its scarcity decreases and additional water is used for less important uses (washing cars several times a week, for example). Just as the price at which poor countries gain from sales goes higher and higher the more that is sold, so the price at which the rich country gains from purchases goes lower and lower the more that is bought. Once these two prices pass each other, nothing further is to be gained from the transactions, and the sales stop.

**Deciding on Ownership Rights: An Interim Escrow Fund**

Agreeing to MYWAS-guided cooperation in no way prevents the parties from asserting their claims to water ownership rights. The system described here does not settle the ownership-rights issue; neither does it pretend to do so. However, this way of thinking about water should make negotiations more tractable. But would not instituting trade in water permits and cooperation in infrastructure require that ownership rights first be settled?

Although settlement of ownership rights issues is very desirable, the answer is “no.” The parties could establish a neutral or jointly managed escrow fund into which they would each pay (at MYWAS shadow values) when using the disputed water sources. The resolution of the ownership question would then become a matter of resolving the ownership of the escrow fund.

Given that the optimal allocation of water usage does not depend on the allocation of water ownership, this would permit the parties to gain the advantages of WAS/MYWAS cooperation while still asserting their ownership claims. The fact that the gains from trade in water permits can be quite large relative to the value of water ownership rights themselves means that there is no need to wait to reap the benefits from trade simply because it is difficult to settle a matter of relatively small monetary significance. None of this denies the proposition that water ownership rights can be of great non-monetary significance.

**The Significance of Ownership of Particular Water Sources**

Ownership of particular water sources may be desired for historic, religious, emotional or symbolic reasons. The Jordan River stands as an apt example. But these reasons have little to do with the value of the water involved, and hence should not stop trading in permits to use the water from the source. Rather, such reasons are related to land claims and boundaries.

We have examined the economic consequences for a MYWAS agreement if
Israel were to retain its present share of Jordan River ownership and were to withhold the corresponding water from a MYWAS agreement. In such a case, all parties to the agreement would have lower benefits than if the water were not so withheld, but Israel would experience the greatest loss in that regard.

**Security Considerations: Hostages to Fortune**

The major objection to trade in water permits among previously hostile neighbors is likely to be one of security. When an agreement is reached among long-term adversaries, is it wise to rely for water on a promise of cooperative trade? What if the water were to be cut off?

This brings up several points. First, the geographic situation does not change with an agreement to trade water permits. Thus, if an upstream riparian could cut off the downstream water supply in the presence of such an agreement; it could also do so in the absence of that agreement. A system of trade in water permits makes disagreement less likely to happen because it is a system where cooperation is very much in the interest of all parties. Nevertheless, although withdrawal from the trade scheme will hurt the withdrawing party, parties, especially those in the Middle East, do not always act in their best interests. Hence, enlightened self interest is not a reliable answer to the potential problem.

The principal aspect of reliance on an agreement to trade in water permits that raises an issue is as follows. Where such an agreement leads either to the construction of infrastructure that would become useless if trade were cut off or to the failure to construct infrastructure that would be needed in such an eventuality, reliance on trade may involve some risk. In effect, in such cases, one or another of the parties may be giving hostages to fortune.

Is this likely in the Israel-Palestine case? With preexisting well-developed infrastructure, Israel is unlikely to have a serious problem. Palestine, however presents a different case. Without water-permit trade and an unfavorable agreement on the West-Bank water ownership rights, Palestine would be forced to build desalination plants in Gaza. However, with trade, these plants would be unnecessary for a long time. Hence if an Israel-Palestine agreement takes the form of water-permit trade and cooperation, Palestine will have an important choice to make as to whether it should build desalination plants regardless. If the plants are built sooner rather than later, they will lose many of the economic benefits from the trade, but without these plants, a problem would occur if Israel were to withdraw from the
trade agreement.

This choice depends on how likely it is that Israel would abrogate such an agreement and what situation would arise. For example, in such an event, presumably the Palestinians would feel justified in extensively pumping the Mountain Aquifer, even if that were not the regionally efficient or agreed-on thing to do. Surprisingly, however, our results suggest that, in the absence of cooperation, the Palestinian need for desalination would not stem directly from the need to use desalinated water in Gaza itself, but from the need to (inefficiently) supply the Southern West Bank from Gazan desalination plants by piping it uphill to the area of Hebron. Hence, the apparent crisis caused by an Israeli abrogation of a cooperative water treaty could be overcome by Palestinian pumping of Mountain Aquifer water beyond the amounts permitted by the water treaty, doing so until the needed desalination facilities can be built.

*What If There is a War?*

Suppose that a war were to break out for non-water reasons. Could water play a part in such a conflict? That possibility certainly exists, although we point out that, during the second intifada, this did not happen, and, the joint Israeli-Palestinian Water Committee even continued to meet regularly.

The fact that water is not worth waging conflict over does not mean that water cannot be utilized in war. Indeed, use of our methods for cooperation in water requires a general wish to find ways to cooperate and reach a peaceful agreement. We hope that we have shown a way to do that in water that might lead to other forms of cooperation.

**The Future of MYWAS**

Although MYWAS has been developed in connection with the Middle East, its use and usefulness are not restricted to that region. Indeed, every country in the world could benefit from the application of the tools to the efficient management of its own water system, especially the planning of infrastructure projects in the presence of broader social values regarding water.

The use of MYWAS to resolve water conflicts is equally important, and such use is not restricted to the Middle East; it can be applied to all cross-border and cross-sectoral water disputes. Water can and should be removed, globally, as a possible *casus belli* or even intense inter-regional or inter-sectoral tension.

While the obstacles to peace in the Middle East are many, water should not be among them. Rather, water should rather serve as a source of beneficial cooperation. These same lessons apply globally. Where there is regional cooperation and efficient management, the problems of water shortages can be greatly alleviated. Properly sponsored and understood, MYWAS presents a great opportunity, both in the Middle East and around the world.
Notes

2 We bring Fishelson’s numbers up to date.
4 See Fisher, et al., op. cit., pp. 11-14, for a detailed explanation.
7 A similar, but more complicated proposition to that in the text holds if there are capacity constraints on the conveyance line.
8 The map in Figure 1 shows the name of the large lake on the Jordan River as “Sea of Galilee.” That lake is called “the Kinneret” by Israel and “Lake Tiberias” by Jordan and Palestine. The map is adapted from Aaron T. Wolf, “A Hydropolitical History of the Nile, Jordan, and Euphrates River Basins”, in A.S. Biswas (ed.) International Waters of the Middle East from Euphrates-Tigris to Nile, ed. Asit K. Biwas. (Oxford: Oxford University Press), 1994, p. 27.
9 It will be noticed that we have not marked the map with the names “Israel” and “Palestine.” That is because we do not wish to prejudge the ultimate borders that may be agreed upon.
10 The occasional appearance of zero gains from bilateral cooperation between Jordan and Palestine is due to rounding error.