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Value of moving from central planning to a market system: lessons from the Israeli water sector

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Abstract

This paper explores the implications of the transformation of the system of water resources allocation to the agricultural sector in Israel from a one in which allotments are allocated to the different users without any permission to trade with water rights. A mathematical planning model is used for the entire Israeli agricultural sector, in which an 'optimal' allocation of the water resources is found and compared to the existing one.

The results of the model are used in order to gain insight into the shadow price of the different water bodies in Israel (about eight). These prices can then be used to grant property rights to the water users themselves in order to guarantee rational behavior of water use, since now one can sell their rights at the source itself. The implication is clear with regard to any possible movement towards a market system in any other sector. From the dual prices of the primal problem we can forecast the equilibrium prices and their implications for the different users. The central government does not have to interfere with the market mechanism because, as will be shown, every farmer has the option to sell his right or to use it. As participation in the market is voluntary, every farmer makes a decision that is both individually and socially rational. However, in moving from a central planning allocation to a market mechanism, the government has another task, which is to *grant* the property rights in order for the market to begin to evolve. It is not guaranteed that under any initial allocation a decentralization of the system will benefit *all* the regions but at least part of the problem is to be resolved between the regions themselves.

As the results shows, there is a potential budgetary benefit of 28 million dollars when capital cost is not included and 64 million dollars when they are included.

1. Introduction

The state of Israel is commonly regarded as a prototype of sound management of water. This reality is in fact very different. While Israel has done well at the micro level in ensuring that water will be used as efficiently as possible for the single crop or field, it has done much less well

at the macro level, where its decisions on how to allocate water have brought the country to a severe water crisis.

Statistics on the balance of water use and water potential in Israel show that during the 1970's and the 1980's there was an 'overdraft' in the water budget of about 5% of the total average water supply. This brought the state in 1990 to a

situation in which a whole year's worth of water was missing from its reservoirs. The drought in that same year finally brought the issue to the public eye, and resulted in the release of the Israeli water commission from its duties.

Two related factors were main precipitants in this crisis. The first one was the unrealistic water price that the agricultural sector was required to pay for its water use, while the second reason is the strict water allotments that farmers were not allowed to be traded with. The relation between these two reasons is that when prices do not reflect the true value of the water, there should be another mechanism to allocate the water between its users. The existing mechanism is based upon the historical allotment privilege assigned to the agricultural sector. However, as experience has shown, this non-market mechanism led to the problematic situation described above.

In this paper, I will try to analyze hypothetically what would happen had the state moved to a market mechanism from the *given* system. There were suggestions to raise the price of water for the farmers without changing the quota system. This, however, would worsen the farmer's situation and would result in a massive lobbying against the plan. In this paper we suggest an alternative plan that treats the water allotments as commercial water rights. This actually internalizes the problem for the farmers since they can either use the water or sell it at the prevailing water price and profit by doing the latter.

The results of this exercise should indicate the value of institutional change in the Israeli water sector. It will be shown that, sometimes, the investment in institutional change is cheaper than investment in the 'hardware' component of the water system, such as developing new water resources, water importing, or water desalination.

2. Israeli water sector – an overview

There is a need to distinguish between a hydrological factors and an institutional ones. This is because later on it will be necessary to combine both parts in order to gain insight into the problems and the suggested solutions.

2.1. Hydrological description and water potential

Israel, like the other middle-east countries, is characterized by a semi-arid climate. This kind of a climate does not permit the farmers to solely rely on rainfall alone, but rather to rely on irrigation as well as rainfall. However, reservoirs similar to rainfall are a major constraint upon the agricultural sector.

While about 10 million cubic meters (mcm) of rain falls over Israel, less than 20% reaches the main reservoirs. Usually, replenishment occurs in the winter, while the major irrigation season is the summer. Another problem is that water accumulates mainly in the northern part of Israel, but is mainly utilized in the central part (for non-agricultural uses) and the southern part (for irrigation). The distribution of the water resources (which is also the water potential) is described in Fig. 1.

As can be seen from the figure, there are three large water reservoirs, one medium one and four small ones. Among the largest three, one, the sea of Galilee – is an open reservoir, while the other two are underground reservoirs: the coastal plain reservoir and the mountain reservoir. Together with the western Galilee reservoir, which is the medium one, they include about 1300 mcm of available annual supply. The other four small ones contain all together a total *fresh* water supply of about 225 mcm. Thus, the total fresh water supply is slightly more than 1500 mcm.

In order to facilitate water transfer from the north to the south, a national water carrier was built that is augmented by a network of regional conduits. This carrier pumps water from the sea of Galilee, an elevation of about 210 m *below* sea level, to an elevation of 152 m *above* sea level. From there it flows by gravitation to the coastal plain, where most of the water is needed either for direct consumption or for augmenting the major reservoirs. Consequently, today there is a direct linkage among all major reservoirs.

Apart from this fresh water resources there is an additional water resource which is currently being used and is based on marginal water. This amount adds about 300 mcm of water to the existing potential supply. However, questions re-

Fig. 1. Distribution of water resources in Israel.

garding the development of these marginal resources should be considered against other alternatives, such as institutional change, rather than physical development as will be discussed later on.

2.2. Institutional setting

In Israel, water resources are considered to be a national resource. They are controlled by the

government in terms of planning and allocation to potential users. Historically, public involvement was necessary because of the interdependence among water users, a fact that is not unique to Israel (Hirshleifer et al., 1960). During the early years of the state of Israel water was not rationally priced, but was instead heavily subsidized because a major goal of the young state was to support settlers in the distant regions, especially in the south where a declared goal of the Zionist movement was to “turn the desert green”. This mixture of the government role, dealing with market failure on the one side but as a political entity with a declared goal of preferring the farm sector, on the other, created confusion among those who tried to analyze the problems and to suggest solutions. Indeed the government had contributed itself to the inefficiency in utilizing the water resources.

The legal situation was formalized in the ‘water law’ (Israel Ministry of Agriculture, 1968) in which water was treated as public property. It authorizes the state to allocate water for the various uses and users, where water prices should in principal be equal among regions. The allocation is done on the basis of quotas, that were considered to be non-transferable.

This system of centralized water allocation created economic inefficiencies that are well-known and have been described by economists in Israel as well as elsewhere (Kislev, 1991; Mosenzon, 1988; Seckler and Young, 1978; Anderson, 1983). As will be shown later on, the rigidity in the quota allocation, which prevents water from being sold or bought at a given market price, causes some farmers to use *more* water than they really need, while others who would be willing to buy the water are not able to do so. The consequence of this policy is demand for water that is not based on price signals but rather on the domestic political situation of the different sectors, which of course does not have anything to do with efficiency at all.

Back in the seventies a committee of experts was established (Kneese, 1976). They suggested a change in the system of non-transferable allotments to a water pricing mechanism that would play a role in the water’s allocation. However, the

conservative attitude won, and the inefficient and rigid mechanism has continued ever since.

In 1990 after almost 3 consecutive years of rainfall below the average, the 'overdraft' reached a record of about one year of total water consumption which was estimated then by about 300 mcm. This resulted in a special report of the state comptroller which in turn was the major cause for firing the water commissioner of Israel.

The following years since then were characterized by a severe water allotment cuts which reached in some years up to 50% of the previous water allocation to the agricultural sector.

2.3. *Water consumption*

Because agricultural water prices are subsidized more than those for non-agricultural uses, a priority is given in water allocation with regard to the last two sectors. Since the quantity demanded by these sectors is relatively fixed (Gibbons, 1986), agricultural water consumption is derived from available supply less consumption by the non-agricultural sectors. The estimated consumption for both industrial and domestic water use is about 600 mcm (Water Commission Agency, 1993) so the derived agricultural water use should be about 900 mcm (1500–600, as noted in Section 2.1). As was mentioned earlier, there has been an average overdraft of about 100 mcm per year for high-quality water so by 1990 there was a whole year's overdraft in the reservoirs.

3. Alternatives for dealing with water allocation

3.1. *Price mechanism*

The role of prices in any economic system, including the water sector, should bring about several conditions that guarantee efficiency of production and consumption. At any given *efficient price*, there will be water withdrawals, such that the marginal cost is less than or equal to price. This amount of water will then be consumed only by users for whom the value of water is greater than or equal to price. Finally we

require an equilibrium condition, that means, price at which the quantity demanded should be equal to the quantity supplied. These conditions are efficient in the sense that they maximize the social value of water and its value added.

This simple well known truth was ignored by the water policy-makers in Israel. While an average water unit costs about 34 cents to produce, the agricultural sector pays about 16 cents per m^3 . This gap between the real production cost of water and its price to the farmer has created the inefficiency that results in a higher demand for the water such that equilibrium is not reached. As water must somehow be allocated according to supply, this situation brought about quotas for water. However, because the planning authority does not have full information on the economy, it resulted in both a decline in the value added of water as well as pressures from different groups for more water at the cheaper price. The latter was the reason for the 5% yearly 'overdraft'.

The subsidy for water includes two parts. The first is recorded as the difference between production cost and consumer price. The second one is not even mentioned in the official records, and is concerned with the capital and depreciation of the water system, such as the national water carrier. The capital component is the largest one and was estimated to be in a ratio of 2:1 with regard to the maintenance cost (Mosenzon, 1988).

The other component that should be priced is the scarcity rent, which should be added because water cannot be 'produced'. Rather it is a natural resource limited by nature. If at a given production cost there is still excess demand, the added scarcity rent reflects this value that would equate supply to demand.

This can be illustrated in Fig. 2. Suppose that, due to the failure of the price system to equate demand to supply, water is allocated by historical quotas. In the figure there are two individual VMP curves. Suppose that over the long run it is impossible to use more water than exists, but the quotas cannot be transferred. It is well known that optimality is achieved when both VMP's are equal, that is, at (Q^*, P^*) . The initial allocation is, however, at $\bar{Q}$. That is, individual 1 gets $\bar{Q}$ and individual 2 gets the rest $(W - \bar{Q})$. This initial

Fig. 2. Two individual VMP curves when water quotas cannot be transferred.

allocation is not optimal, of course, as it fails the VMP equality condition. User 1 uses less water than he should. The dead weight loss is given by the area OAB. The efficient water price would be at P^* if we open the market for the quotas. If the price is set at P_1 there will be an excess demand in region 1, while if the price is set lower at P_2 , there will be an excess demand in both regions.

There is no need, however, for 'planning' if we set the price at P^* . The two conditions for efficiency are met. VMP is the same in both regions and supply equals demand. The problem lies with the fact that a cost-benefit analysis will reveal that at least part of the users have become worse off by moving from P_2 to P^* . The net benefit for region 1 (total value of the water, less payment for that water) when it uses $\bar{Q}$ at the price of P_2 is given by $FACP_2$, while the net benefit when it uses Q^* at the real price of P^* is given by FOP^* . For region 2, the net benefit is changed from $GBCI$ before the change, to a net benefit of OGJ , after the water price is raised to P^* .

It can be seen that, while user 2 is worse off, the change in the situation of user 1 is ambiguous without an empirical investigation. All in all, the situation of the two users is worse off by comparing total net benefit before the change ($FACP_2 + GBCI$) to the net benefit after the change ($FOGJP^*$). This is the reason for the opposition by the agricultural sector to such a solution. While

such a change increases efficiency, it means the farmers are worse off.

3.2. Potential for water markets

Water markets can be viewed as the mirror of raising the price of water to its 'real' value but with additional benefits, which will be discussed below. This has been discussed already in the literature (Vaux and Howitt, 1984; Saliba and Bush, 1987; Randall, 1981; Anderson, 1983). This approach integrates the historical quotas with efficiency by removing the barrier to trade among water users. In this case, the actual water price should and indeed would be equal to the efficient price, P^* .

If we turn to see what happens to our two users in Fig. 2, we find that in region 1, while paying an extra $KOQ \cdot \bar{Q}$ for the water, it received an additional value of $AOQ \cdot \bar{Q}$, that is larger. Therefore their situation has been improved. Region 2 has sold $(Q^* - \bar{Q})$ units of water at the equilibrium price, P^* , and received $KOQ \cdot \bar{Q}$ in exchange. There is also a loss in the value of the sold water, which is $BOQ \cdot \bar{Q}$, but as can be seen from the figure it is smaller. Both regions, therefore, have an interest in entering the market, because they both gain by doing so.

It should be emphasized that the first approach worsened the farmer's situation because there is a shift of revenues from the agricultural sector into the national budget. If it were to be distributed back to the farmers with *no connection* to the amount of water use, then the two approaches would be similar. However, this is very hard to do in reality and here lies the advantage of the markets. There is no need for the government to enter the market once it operates. All it has to do is decide the initial allocation.

The same argument holds for a reduction in water use to its annual water recharge. A policy of compensation for *not* using the water may be found cheaper than subsidizing the water. It should be noted that, although this is true from an economic point of view, it comes at the expense of other ideological values, which should be included in the bottom line.

4. Empirical setting

We will continue now in several stages to analyze the Israeli water sector, and the effect of proposed privatization of the allocation of water, the income of the agricultural sector, and the national budget. We first describe the existing situation and its implication on both the amount of planted area and the value of water to the farmers, as well as the implication to the national budget due to the subsidy when capital cost is taken into account and when it is not.

This Governmental spending for subsidizations will be the basis for comparison to the alternative policy suggested in this paper. This policy will open the market for water rights with and without capital cost. This can be done either through granting the rights and their monetary value or through real water pricing and its implication on the farmers. Here there is no subsidy involved but there is a decrease in the income of the agricultural sector. This, however, is smaller than the subsidy involved, because water use is rational when the price is real, while it is not rational under a subsidized price.

The optimal allocation that will be found can be used to derive the market solution by considering the shadow price of the different reservoirs. These imputed prices reflect the value of the property that will be part of the farmers' endowment. In that case, they can rationally decide to use them or to sell them.

4.1. Model

There are eight reservoirs that comprise the supply side, while ten regions comprise the demand side for water in Israel. Estimates of the cost involved in moving water from each supply region to a demand region were taken from the water supplying agency of Israel (Mekorot, 1993). A schematic representation of the different regions is shown in Fig. 1. There are records on about 44 crops in the Ministry of Agriculture, but in order to simplify things we chose to concentrate on five aggregates: Field crops, Vegetables, Citruses, Orchards and Flowers. For each one of them, data on the variable costs of production

per unit land were used (Israel Ministry of Agriculture, 1992). We are interested in the net returns per unit of water. This is calculated by subtracting all of the costs, except for that paid for water, from the return per land unit and dividing the difference by the average amount of water used for that crop. Domestic and industrial water use were treated as constraints for each region.

An overall linear programming model is used for the optimal planning stage. Later on it will be shown how the results of this model can be interpreted if we want to move to a market system. The model is given by:

$$\text{Max } Z = \sum_i \sum_j V_{ij} W_{ij} - \sum_S \sum_i C_{Si} W_{Si} \quad (1)$$

S.T.

$$\sum_i W_{Si} \leq \mathcal{W}_S \quad S = 1, \dots, 8 \quad (2)$$

$$\sum_j X_{ij} - \sum_S W_{Si} \leq 0 \quad i = 1, \dots, 10 \quad (3)$$

$$D_{ij} = W_{ij}/a_{ij} \quad \begin{matrix} i = 1, \dots, 10 \\ j = 1, \dots, 5 \end{matrix} \quad (4)$$

$$W_{in} = \mathcal{W}_{in} \quad i = 1, \dots, 10 \quad (5)$$

$$\sum_j D_{ij} \leq \mathcal{D}_i \quad i = 1, \dots, 10 \quad (6)$$

$$\sum_i D_{ij} \leq \mathcal{D}_j \quad j = 1, \dots, 5 \quad (7)$$

$$\sum_S W_{Si} = \mathcal{A}_i \quad i = 1, \dots, 10 \quad (8)$$

where V_{ij} is value added of one unit of water of crop j at region i (in \$/cm) W_{ij} water allotment to crop j at region i (in cm), C_{Si} average transfer cost of water unit from region S to i (in \$/cm), W_{Si} amount of water transferred from region S to i (in cm), $\mathcal{W}_S$ water potential in region S (in cm), D_{ij} amount of land in region i devoted for crop j (in dunam, which is 0.1 ha), a_{ij} water consumption coefficient of crop j in region i (in cm), W_{in} water for non-agricultural use in region i (in cm), and $\mathcal{D}_i$ amount of potential irrigated land potential in region i (in dunams), $\mathcal{D}_j$ amount of land

quota for crop j (in dunams), and $\mathcal{A}_i$ water allotment in region i (in cm).

Eq. (1) is the objective function, which is the difference between the gross value of water in the agricultural sector and the total value of supplying that water. Eq. (2) is actually a set of eight equations, one for each reservoir, which represents the scarce amount of water at each source due to the limitation of not letting the total use of water from that source be larger than the average recharge. Eq. (3), which is a set of ten equations for the ten regions, gives a restriction regarding the use in each region. The total amount of water used in each region cannot be greater than the total amount transferred to that region. Eqs. (4) and (5) are identities. Eq. (4) transforms amounts of water to land units, while Eq. (5) represents the non-agricultural water use constraint. Eq. (6) represents the physical limitation of land devoted to agriculture in each region, and thus contains ten equations. Eq. (7) is a quota restriction for each crop that implicitly deals with the fixed price, and therefore contains five equations. The last equation, (8), is the constraint on the water allotment to each region; that is, the total amount of water to each region, transferred from all of the regions, cannot exceed the given water quota to that region.

We turn now to a discussion on the relation between this model and the market mechanism,

and will then describe the results of applying the model.

4.2. Dual approach

It is well known from the theory of optimization that the primal and dual of the same problem will generate the same results. In our case, the dual approach to the problem is the minimization of the sum of resource (or constraint) prices, multiplied by their use; that is, the shadow prices of the different resources. In our system we actually have five constraints if we ignore the identities. Therefore, we have five sets of shadow prices that contain 53 values in total. The model should look like:

$$\text{Min } R = \sum_S \mathcal{W}_S \lambda_S + \sum_i \mathcal{D}_i \lambda_i + \sum_j \mathcal{D}_j \lambda_j + \sum_i \mathcal{A}_i \lambda_i \quad (9)$$

S.T.

$$\sum_S \lambda_{Si} + \lambda_i + \lambda_j \geq V_{ij} \quad \begin{matrix} i = 1, \dots, 10 \\ j = 1, \dots, 5 \end{matrix} \quad (10)$$

where λ_S represents the shadow value of reservoir S , λ_i is the shadow value for the area in region i , and λ_j is the shadow price of the specific crop quota. In other words, the total imputed price of using the national resources

Table 1
Value of water to the farmers and to the state – current conditions

Regions	Water use (1000 cm)	Land use (dunams)	Profit to farmers (1000 \$)	Profit to state	
				No capital cost (1000 \$)	W /capital cost (1000 \$)
Galilee	106,589	175,144	56,260	43,379	13,406
Acre	50,742	191,152	23,570	24,681	17,396
Nazereth	4,853	11,156	1,228	519	– 277
Afula	98,232	170,421	37,453	22,754	6,597
Bet-Shean	44,433	96,992	10,073	12,506	5,190
Jerusalem	48,752	73,990	23,836	24,370	16,314
Hadera	101,164	187,496	46,034	42,711	26,002
Raanana	88,944	153,980	29,813	30,462	15,797
Rehovot	124,807	238,216	45,897	47,263	26,669
Negev	204,983	423,254	52,037	20,616	– 13,001
Total	873,499	1,721,791	325,380	269,262	114,092

Table 2

Water, land and profit allocation under optimal allocation with no capital cost

Region	Water use (1000 cm)	Land use (dunams)	Profit (1000 \$)	Shadow prices	
				Per 1 cm (cents)	Per dunam (\$)
Galilee	82,501	175,144	52,175	18	77.9
Acre	103,918	191,152	49,977	18	77.9
Nazereth	19,085	11,156	12,099	16.5	1035.2
Afula	27,839	108,835	5,126	23.1	0
Bet-Shean	44,433	96,992	5,612	18	77.9
Jerusalem	13,919	54,418	2,563	21.8	0
Hadera	153,684	187,406	19,205	16.5	1037.4
Raanana	110,760	153,970	113,645	17.7	173.9
Rehovot	166,870	238,216	30,281	18	77.9
Negev	34,965	163,253	6,438	33.5	0
Total	757,974	1,380,631	297,121		

should be equal to the value added of that specific crop. Eq. (10) consists of 50 equations regarding the number of crops in the various regions. However, the values of the λ 's are prices that will prevail in a market economy, so they can be considered an indication of the value of the resources that each region holds. This allows us to predict the amount of water to be transferred from each region to another, as well as the payment from and for each region.

It was decided to drop the individual allotment for each region, and to concentrate on the value of water at the source. This is because if one region trades with another there is no need for the water to be diverted to the region that sells,

rather it can be sold at the source at the prevailing price.

4.3. Current situation

The results of the application of our model are shown in Table 1. As can be seen, the total estimated use of water is about 873 mcm. The total land devoted to irrigated agriculture was found to be 1.72 million dunams.

The budgetary implication of such a crop pattern should be considered on the basis of a comparison of the value of the water to the farmers versus the value of the water to the state. As can be seen from Table 1, we have divided the value

Table 3

Water, land and profit allocation under optimal allocation with capital cost

Region	Water use (1000 mc)	Land use (dunams)	Profit (1000 \$)	Shadow prices	
				Per 1 cm (cents)	Per dunam (\$)
Galilee	23,360	81,006	1,613	27.4	0
Acre	24,608	58,007	1,005	23.5	0
Nazereth	14,418	3,240	3,691	23.5	0
Afula	22,384	40,698	3,834	23.5	0
Bet-Shean	40,161	64,698	19,674	23.5	0
Jerusalem	11,857	45,998	2,483	27	0
Hadera	64,256	103,514	27,577	23.5	0
Raanana	148,368	153,970	81,789	19.6	23.96
Rehovot	181,792	220,479	30,393	23.5	0
Negev	30,084	35,008	5,801	52.3	0
Total	561,288	806,618	177,859		

to the state into with and without capital cost; because the infrastructure is already in place. Hence it would be rational to examine only the variable cost. The price that the farmers pay is taken to be the current one, but in the calculation of the profit to the state, the real cost was, of course, taken into account.

It was found that the value of water to the agricultural sector is about 325 million dollars, which brings us to an average value of 37 cents per cm to the farmer. If, however, we calculate the budgetary consequence of that policy, we see that the profit is only 269 million dollars and 114 million dollars with and without capital cost respectively. That means a national value of 31 cents and 13 cents per cm with and without capital cost. In other words, the official subsidy is about 7 cents per cm plus an additional 17 cents per cm, which is a subsidy for the infrastructure. In total, it adds up to 56 million dollars, which is the official subsidy, while the real subsidy comes to 211 million dollars.

4.4. Optimal allocation

The allocation is optimal in the sense that it does not take property rights into account but rather treats it as a social planner case. The results are shown for the case with no capital cost included (Table 2) and where capital costs are included (Table 3). Tables 4 and 5 describe the shadow prices for the land and quotas, respectively.

As can be seen from Table 2, the profit to the agricultural sector is now 297 million dollars. This

Table 5

Shadow price for crops quotas per dunam (\$)

Crop	Without capital cost	With capital cost
Field Crops	0	0
Vegetables	24.75	0
Citruses	112.50	82.98
Orchards	473.39	439.97
Flowers	2075.50	2018.79

is a decrease of 28 mill. dollars. However, the current subsidy was found to be 56 million dollars which is twice the loss to the farmers. Clearly there is a place for a Pareto improvement. It should be noted from Table 2 that the irrigated land is decreased by 20% due to a decrease of 13% in the total amount of water use. The shadow price indicated in Table 2 is the willingness to pay for an additional unit of water and an additional unit of land, but the interesting table for the market solution is Table 4. In that table the shadow prices for the different reservoirs can be implemented if we turn the water allotments into tradeable property rights.

A simple example will illustrate the point. The amount of water (from the coast reservoir) diverted to the Negev in the south fall while the amount to Raanana region in the center will increase. In the current situation, water is diverted from the coast reservoir to the Negev. The unit value at the reservoir is 8.6 cents. The average water transfer cost is about 28.86 cents. If we use the right to trade these water, we save both costs, which brings the unit value of water to a total of 37.46 cents per cm. Note, however, that the unit value of water or the willingness to pay at the Negev is only 33.5 cents per cm, which is smaller then the option to sell (but higher then the transfer cost, which explains the massive water use in that region). In the Raanana region, the considerations will be the following: They should pay a market price of 8.6 cents for a unit of water plus 9.1 cents to deliver the water. Looking at Table 2 we note that the joint sum of the last two numbers is 17.7 cents per cm, which is exactly the willingness to pay at that region.

The same kind of analysis can be done from table 3, which includes capital costs. As can be

Table 4

Shadow prices for the reservoirs

Names	Without capital cost (cents)	With capital cost (cents)
Sea of Galilee	0	0
Mountain	2.8	1.1
Coast	8.6	3.9
Western Galilee	3.8	0
Carmel	0	0
Lower Galilee & Valleys	2.8	4.2
Jordan Valley	11.8	11.2
Arava	4.3	0

seen from the table, the picture here is clearer. Due to a decrease in the amount of water used by 36%, there is a decrease in irrigated land by 53%. This brings down the farmers profit to 178 million dollars, which is a loss of 147 million dollars relative to the current situation. This is, however, substantially lower than the existing subsidy, which is 211 million dollars.

The benefit from trade are obvious also in this case but will not be demonstrated here because the analysis is identical to the case without capital cost. It should be noted, however, that the rental value of the different reservoirs decreases when capital cost is incorporated. The reason for that is the lower demand for water when the extraction cost is rising.

It is important to note that comparing to the current situation, decentralizing the system will not solve by itself the entire problems of the ten regions. The reason for that is that now it is important were do the different regions get their water from in the first place. If we take a region that receives most of its water from a reservoir which the shadow price on it is zero, privatizing the system not only that will not benefit but may harm him since now he has to pay the full cost of withdrawing the water without any opportunity to sell the water to an interested party. If the government does not want to harm the situation of nobody, it will have to compensate that region directly. However, part of the total compensation will not be needed any more due to voluntary exchange of water rights between the regions.

5. Summary

This paper analyzes the Israeli water sector, and the change in the major components when there is a change in the water policy in Israel. But, more importantly, this research attempts to show that if we open the water market for trade in water rights, then the existing rights can be used as a tradeable property that can either be used or sold. This is the main advantage that the market has, compared to the alternative were the government will have to deal individually with each region on the value of water and its derived

compensation. The fact that participation in the market is only voluntary is the reason that there are actually no losers that need to be compensated by the government.

Recent estimations of the real desalination cost estimated it in about 80 cents per cm. Clearly, as this paper shows, this project is not economically efficient under the current conditions because the problem of the so called 'water scarcity' can be solved more cheaply through institutional change (tradeable water rights) rather than through physical change (e.g., desalination).

Finally, it should be noted that while there is an increase in the efficiency of water use, there are still alternative non-economic goals that are hurt by the proposed change. Taking, for example, the case with capital cost, a decrease in governmental spending by 64 million dollars (which leaves the farmers in the same financial conditions) should be weighed against a reduction of 53% in the amount of irrigated land. This is, however, a question to be answered by policy makers rather than economists.

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This work is dedicated to R. Harpaz.

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