The Reform in Israeli Agricultural Water Pricing: A New Way or No-Way*?

by

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1. Background and Current Situation

1.1 *The water crisis*

Chronic scarcity of water is a fact of life in Israel where aggregate demand exceeds the supply of fresh water in a largely semi-arid environment. The commonly agreed-upon policy of maintaining a long term balance between the potential of available water and the utilization of water resources could not meet consumer pressure, especially the pressure of the agricultural sector. The Israeli water economy is in the midst of a severe crisis whose main features are a shortage of fresh water and a steadily increasing deficit, a poor and declining ground water quality (gradual salination) and a pollution of most of the streams by untreated urban , industrial and agrochemical effluents (Zaslavski, 2001). Detailed presentation of the supply and demand situation in Israel is out of the scope of the current paper. However, for the sake of completeness, some aggregate data are presented in Table 1.

[Table 1 about here]

The main quantitative expression of the crisis is a sharp decrease in the ability to pump groundwater without crossing predetermined red lines, where the agricultural sector bears the brunt of the necessary cuts. Since all significant natural water resources in Israel are largely overexploited, attention is being increasingly focused on the development of unconventional water resources, namely, desalination of seawater and recycling of sewage effluents (Table 1). The supply of reclaimed sewage is expected to grow substantially due to an increased water supply for the growing domestic and industrial sectors, and the expansion of irrigation with recycled effluents. Indeed, a large-scale transition in agricultural water use, from good quality water to treated wastewater, is expected to occur within the next few years (Table 1). This shift requires the development of many more environmentally safe water treatment plans, reservoirs and conveyance systems. Treated wastewater can also be used for river restoration. Unfortunately, the rate of the agricultural sector's transition from freshwater to recycled wastewater is rather slow. As a result of the slow transition, in the short run it will be incumbent on Israel to reduce drastically the supply of freshwater for agricultural use. This may have significant consequences on the agricultural sector, and its recovery in the future is uncertain. In the event of drought in

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the coming two to three years, the supply of water for domestic and industrial needs will also be in jeopardy.

Among many factors contributing to the water crisis is population growth and economic development, resulting in an increased domestic and industrial consumption of freshwater. The transfer of freshwater to Jordan as required by the peace agreement and the over-pumping from the western mountain aquifer by the Palestinians, both contribute to the crisis. Some decline in the natural renewal of water resources due to global climatic changes in the eastern Mediterranean region may result in a gradual decrease of the water potential. Additional crucial factors contributing to the crisis are inefficient institutional and administrative mechanisms for water allocation and control, and poor decision-making culture (hydro-politics). The next subsection is a brief presentation of these factors.

1.2 *Institutional and Administrative Framework; Major Conflicts*

There is no private ownership of water in Israel. By the Israeli Water Law of 1959 all water sources are publicly owned and their utilization is controlled by the Water Commissioner. A single government-owned company, Mekorot, operates the National Water Carrier (NWC)[1] and provides approximately 60% of the total water supply; regional cooperatives and municipalities and private well owners supply the rest.

The allocation is administrative: the Water Commission issues permits for production (extraction) to suppliers as well as allocations (quotas) for consumers. In the past, these quotas constrained the use of water in agriculture. However, more recently, with higher prices for water and lower prices for agricultural products, the agricultural sector fails to exploit all of its allocation. Households, on the other hand, were never constrained in their consumption and formal quotas for this sector were abolished several years ago. The current water laws do not permit trading in water quotas, and the transfer of water rights between sectors such as agriculture and industry is unlawful.

Decision making and management relating to the water economy take place in many forums, and is greatly affected by special interest groups each pulling in its own direction (Soffer, 2001). The person officially in charge of determining water policy is the **Minister of Infrastructure** or the **Minister of Agriculture** depending on the existing governmental coalition. The **Water Council** is a

[1] The NWC, which is made up of canals and pipelines, was constructed almost 40 years ago, and is designed to divert the Jordan water from the Sea of Galilee to the Negev desert, thus enabling the settlement of this extremely arid region. The uniqueness of this carrier goes beyond the transferring of water from the north to the arid south. It became an operational tool, which connects all three major water sources into one system (Kislev, 1993). During the wet winter season, when even the southern part of Israel gets some precipitation, water is still being pumped from the Sea of Galilee and injected into the Coastal Plain and the Mountains aquifers, to recharge the declining water tables. During the summer time, irrigation all over the country is a must, because there is no precipitation between May and November and water is being pumped from both the Sea of Galilee and the aquifers.

national entity appointed by the government to advise the Minister of Agriculture on a wide range of water issues, including water pricing.
The authority in charge of managing the water system is the **Water Commissioner** appointed by the government and headed by the water commissioner. The commissioner issues permits for production (extraction) to suppliers as well as allocations (quotas) to agricultural consumers. The latter is coordinated with the **Ministry of Agriculture** and requires his agreement.
Mekorot is Israel's national water company, responsible for most of the supply and maintenance activities , including the operation of the National Water Carrier and the Shafdan.[2] In effect, Mekorot is the only entity with significant financial and operational abilities in the field of water resources. Its role in the overall financial turnover of the water resources reaches about 80% of the sector's business activity, since it operates a water system at high costs, conducts water for long distances and pumps water to elevated locations. The **Ministry of Health** is responsible to determine the standards for purification for all water types and their uses, including authorization of irrigating with recycled wastewater of lands overlying groundwater aquifers and the **Ministry of the Environment** is responsible for preventing water pollution and protecting water resource from contamination.

The **Ministry of the Interior** supervises the local authorities'water and sewage activities. The **Ministry of Finance** is responsible for the overall budget and for the allocation of financial resources (including subsidies) to the water economy and to Mekorot. Structural changes and major developments (like massive recycling of sewage and desalination of sea-water) cannot be carried out without the approval of this ministry. Additional influential forums include the National Sewage Administration, Lakes and Stream Authorities, Parliamentary Finance and Economic Committees, Jewish National Fund, consumers' representatives in the Water Council and a very powerful agricultural sector that had controlled the Israeli water resources during its first years (Sofer, 2001). The implications of the large number of parties involved in the arena of water management that hinder initiatives and changes yield a bureaucratic maze and lack of synchronization of the different needs that the water economy has to fulfill.

Major Conflicts

- Conflict between the urban and the agricultural sectors on the limited resources of freshwater. All of the inelastic domestic demand in the steadily increasing urban sector is covered by freshwater supply, and thus a large-scale transition in the agricultural water use from good quality water to reclaimed urban and industrial wastewater is expected.
- Competition between agricultural and ecological utilization of recycled wastewater.

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[2] The Shafdan is a plant for the treatment of urban and industrial effluents of the greater Tel Aviv metropolitan area (which includes more than 30% of the country's population), and is responsible for conveying recycled water to the southern region (Western and Northern Negev) for agricultural use.

- Competition between farmers in the central and in the peripheral regions of Israel for recycled wastewater. Most of the urban and industrial sewage is "produced" in the coastal plain, in the center of the country, while most of the irrigated areas are located in the periphery. The costs of constructing new networks to transport the recycled water (assuring that it will not be mixed with freshwater) and the costs required to prepare new facilities to store excess treated water from winter to summer are of major importance. The spatial distribution of aquifers and the environmental costs associated with irrigation above them, which may pollute the underlying groundwater, should also be considered.
- Conflict between the agricultural and the urban sectors regarding the purification standards for disposal set for the cities by the government. Another conflict is about the allocation of the costs and the benefits associated with recycling between the generators of sewage (the municipalities) and the agricultural users. An additional conflict is the issue of assurance for the municipalities that the farmers will not reduce usage suddenly (due to an economic crisis for example) and leave the cities with treated water that cannot be disposed of.
- New and forthcoming partial privatization of water supply is a potential source of conflict between the government-owned company, Mekorot, and private entrepreneurs on two issues: the control of the supply of newly developed water resources (mostly desalinated sea water and recycled wastewater) and the responsibility for the operation of the intra-cities water systems (currently operated by the cities themselves).
- Conflicts between Israel and the Palestinian Authority on the utilization of the Coastal and the Mountain ground water aquifers.
- Conflicts relating to the application of the new proposed reform of agricultural water pricing which will be discussed at length in this paper.

1.3 Current Water Pricing Practices

Prices of water delivered by the national company Mekorot are set by the government, and are based on recommendations of the Ministry of Finance, and the Water Commission, and on an approval by the parliamentary finance committee. The prices are determined in consultation with the Water Council in a procedure which is open to political pressure (skillfully applied by the agricultural lobby). Viewing water prices not as an allocation instrument, but as a means to improve income distribution, water charges depend on the type of use: farmers pay the lowest charges, industry pays larger charges and households pay the largest ones. Within each sector charges do not depend on location: users in all parts of the country face the same charges, regardless of the supply price of water (Kislev, 2002). Private water producers set prices independently.

Tiered pricing exists for agricultural users who pay a reduced price of $0.19 for the first 50% of their quota, a higher price of $0.23 for the additional 30%, and the full price of $0.31 for the rest of the quota (which in most cases is not fully utilized). Industries pay an average of $0.33 per m^3 and cities and towns pay $0.35 at the "city gate." Neither industries nor municipalities pay tiered charges. Households in cities face tiered charges, paying about \$0.68 for the first block (typically 8 m^3 per household per month), \$1.0 for the second block (typically seven m^3 per household per month) and \$1.47 per m^3 for any additional consumption.. In other words, on top of the prices that the municipalities pay to Mekorot for water, they impose on their households two layers of surcharges: one for the water distribution system and for sewage removal, and the other taxes to help finance general municipal operations. This policy may be beneficial for the city in the short-run but it might be very harmful in the long run, when funds will be required for reinvestment and renewal of the old water delivery and treatment systems (Kislev, 1993). Water prices vary by quality. Water with over 400 mg chlorides per liter is charged at a lower rate than fresh water according to its salinity level, with the average price being \$0.16 per cubic meter. The charges for recycled waste water are according to a two-tiered price system: the first 50% of the quota at a higher rate of about \$0.15 per m^3 and the rest at a lower rate \$0.11 per m^3.

The prices charged by Mekorot are subsidized, by the government which covers approximately 20% of the cost of supplying the water. In the past, part of the subsidy was implicit. While Mekorot operated the government-financed NWC, its capital cost was not reflected in the water prices. However, since 1993, Mekorot has been working according to a "cost agreement", under which it purchased the capital assets of the water economy, and their depreciation became a recognized component of its costs. Governmental support has therefore become explicit.

2. Hydro-Politics and the Proposed reform in Agricultural Water Pricing

2.1 Water and Agriculture

The total of cultivated land in Israel is 351,460 hectares. The irrigated areas are 196,998 hectares (56% of the total cultivated area). The continuing scarcity is an excellent economic incentive for breakthroughs in irrigation technologies which were invented in Israel such as drip irrigation and micro sprinklers, that reduce a water loss of up to 20 percent. Computer-assisted irrigation management enhances these results. Despite the modest role of agriculture in the national product (less than 2% of the GDP), it consumes about 60% of the nation's limited freshwater supply for cultivation and export of water (water-intensive crops like cotton and citrus are exported). Although there is a consensus among policy makers and water experts that the supply of potable water (i.e., urban consumption) should receive top priority. Some water experts point out that while water used by industry or tourism is many times as productive as that used by agriculture, water is made available to farmers at about 65% of its price in the cities.

As mentioned above, decisions on water prices are made at the political arena and are affected by pressures of interest groups. Each of them attempts to affect public decisions in its favor. The different interests of the two strongest groups in the Israeli water sector, the workers of Mekorot and the farmers, are discussed in the comprehensive study of Kislev (2002). Here we focus on the latter. The main interest of the farm is to receive a large allocation of water supply at the lowest attainable price. Water is a significant input in agricultural production in arid and semi-arid regions like Israel, and many farmers strongly support their representatives in the political arena. The agricultural lobby is very well organized, and so far, its influence on water policies and pricing decisions has been significant. The share of water costs in the budget of households or in the cost of manufacturing is relatively small. Therefore urban and industrial water users have only little incentive to organize political lobbies and, in effect, they do not compose a strong opposition to the agricultural lobby (Kislev, 2002). The consequences of the success of the agricultural lobby have been over utilization of water for many years, the hydrological deficits, the intrusion of seawater into the coastal aquifer, the contamination of reservoirs, and the reduction of the carry-over capacity of the system. These detrimental effects are among the major reasons for the current severe water crisis. Although still very influential, the agricultural lobby lost some of its political power in the last two decades.

Unlike the urban and industrial sectors, the agricultural demand is elastic and can be reduced significantly if water prices will be increased, and many experts suggest to raise the price of water to the agricultural sector significantly in order to reduce consumption sharply (e.g.,Ravid, 1999; Eckshtein, 2000; Strassler, 2001, Becker and Lavee, 2002). It seems as if it becomes more and more difficult for the agricultural lobby to preserve the situation that has existed for so many years of relatively low water prices. Moreover, it seems that farmers are beginning to understand that the increase of water prices is inevitable. Indeed, steps are taken in the agricultural sector in preparation for a sharp reduction in the amount of fresh water available for irrigation. These steps include both a shift in crop mix toward crops that use treated water of lower-quality and the development of additional environmental-friendly treatment plants to double the amount of recycled water available to agriculture. The government supports the sewage sector at two levels. First, it partially finances investment in sewage and recycling projects in municipalities. Second, it subsidizes the adaptation of irrigation to reclaimed water (storage facilities and new networks).

Agriculture in Israel is seen by many as an enterprise that its national value exceeds its contribution to GNP via food production, which justify governmental support (Netanyahu, 2000; Zaslavski, 2001). It contributes to security by protection of the country's lands, especially at peripheral areas, and by supplying foods at time of emergency, and it also contributes to the environment by protection of open spaces and preservation of the natural and social landscape. In addition, its use of water from various sources and various qualities is flexible at past and present, and it can serve as a safety net for supplying water to local authorities (i.e., households) in times of emergency since it utilizes a large amount of fresh water.

2.2 The Proposed reform

The reform is the result of a recent (and a rare) agreement on significant policy changes in the practices of agricultural water pricing between the two most influential public key players in the Israeli water economy, the Ministry of Agriculture and the Ministry of Finance. The declared goals of the reform are to increase the overall efficiency of water allocation to the agricultural sector, by raising water prices to the level charged for urban use, and at the same time to give farmers incentives, via adequate land-dependent compensation scheme to fulfill their national goal of protecting the land and preserving the landscape. More specifically, the major characteristics of the reform are threefold:

1. Canceling the current tier-pricing system for agricultural water and raising gradually the water prices and the extraction levies, varying by water quality

and equating them within 5 years to the *current* price charged for urban use (namely, water prices will not vary by sector any more). The reform determines *fixed ratios* between prices of water of various qualities (e.g., the price of saline water will be 70% of the price of fresh water and the price of recycled effluents will be 50% of the price of fresh water) which will last "forever." The situation after the adjustment period of five years remains vague. However, it seems as if following the adjustment period, prices of agricultural water will be changed once again and equated "forever" to the existing price of urban water (which will probably be higher in real terms than the current price due to an expensive and a massive desalination of sea water expected to be taken in the near future).

2. Compensating farmers by redistributing to them **all** the state's additional revenues (identical to farmers' additional aggregate costs) resulting from the increased water prices and the extraction levies. The compensation scheme, which will be detailed below, depends on the decision of farmers to cultivate **all** the area in their possession by either a crop mix or a fallow land.

3. A constant annual payment by the Ministry of Finance to the Ministry of Agriculture, independent of water use, aimed at supporting the investment in activities with public good characteristics, like research and development, extension services, land mapping insurance, promotion and marketing of Israeli products at the export markets, etc.

Before proceeding with the details, it is worthwhile to ask why now? What brought the two Ministries who make decisions pertaining to water issues to finally reach an agreement after so many years of a deadlock situation and a history of disputes with regard to the preferred water strategies? The answer that we suggest should be viewed only as no more than an educated guess. We start with the minister of Agriculture (MOA), who initiated the reform. Firstly, he is probably aware of the fact that in spite of the continuous effort of the agricultural lobby, fresh water prices for the agricultural sector increased in the last decade by about 70% (in real terms), without any direct public compensation to farmers[3]. Indeed, since the mid-eighties, aggregate water use by farmers is lower than the aggregate quota allocated for the agricultural sector (i.e., practically, water is allocated by prices of water and products rather than by the administrative quotas). Under the reform, the rise in water prices will be balanced by an agreed upon compensation such that aggregate farm income will not be affected.

In addition, a wide and constant coverage of the current water crisis in the written and electronic media increase public awareness of both the water problem and the tax payers' objection to keep subsidizing agricultural water prices. It seems as if putting the blame for the visible water shortage on the low selling price of water to agriculture is becoming more popular. The MOA probably realizes that raising the price of water is inevitable and that he cannot ignore the increased tension between farmers and non-farmers in Israel concerning the fairness of water allocation among the competing uses.

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[3] "Farmers in Israel were caught in the scissors action of rising water prices and decreasing product prices." (Kislev, 2002).

Additional reasons, which may motivate the MOA to offer the gradual rise in water pricing, include:

(1) Increasing the budget of the Ministry via a constant annual payment of about 100 million NIS[4] for activities with characteristics of a public good. The portion of the Ministry's budget (excluding the high and non-flexible salaries) which can be used to affect various activities of the agricultural sector is very low, and the above increase is significant and will enable the advancement of plans and programs that would otherwise be postponed.

(2) The Ministry of finance stipulated that the transfer of compensation payments to farmers for the administrative cuts in water allotments for the years 2001 and 2002, depends on the application of the reform[5]. The same is applied for the subsidization of farm-level investments in water saving technologies. The foregoing conditions set by the Ministry of Finance can assist the MOA in convincing its fellow farmers not to object the reform.

(3) The expected increase in aggregate cultivated land, especially in the south, is a national goal that will be realized by the reform. The reform may potentially reduce or even stop the process by which cultivated land is deserted as a result of negative profitability.

(4) The major responsibility for carrying out the reform (monitoring cultivated land and crop mix at the farm level, transferring the compensation payment to farmers with some control on its specific distribution, etc.) rests on the shoulders of the Ministry of Agriculture. Some farmers' representatives blame the MOA in using the reform as a means to increase its currently weak control over the agricultural sector,(e.g., Belkind, 2002).

The traditional position of the economists in the budget department of the Ministry of Finance is that there is no water shortage in Israel, and all that is required is to increase water prices so that demand does not exceed the available supply. They constantly call for basing the water allocation on an efficient price system that includes the shadow price or scarcity rent of water and does not vary by sector. Thus, no wonder that the Ministry of Finance agreed to adopt the proposed reform enthusiastically. Israel's ongoing severe security problems have a significant impact on the economy and the reduction of governmental budget is recommended by all experts and it became a top priority of the Ministry of Finance. The expected reduction in agricultural water consumption associated with the reform may ease public pressure for an urgent and large scale investment in expensive desalination plants partially subsidized by the

[4] 1 NIS $\approx$4.7 USD.

[5] These payments are not required by law and are negotiated between the Ministry of finance and the Ministry of Agriculture in a process subject to political pressure of the agricultural lobby.

government, and a consequent reduction of governmental expenses. Moreover, although the reform does not explicitly discuss the role of the current quota system, it seems as if this system will either be canceled altogether or become ineffective due to higher water prices. Thus, compensations to farmers for quota reductions in drought years will be eliminated[6]. The government recognizes the special contribution of agriculture to the national goals of protecting the country's lands and the open spaces and preserving the natural and social landscape, and therefore agrees to keep subsidizing it, but not through the medium of water.

Most farmers do not adopt the economic point of view at large, and they act to advance their short run goals. They request a quota-based allocation of potable water and water price adjustments (i.e., subsidy) based on the ability to pay. At the same time, they advocate the expensive expansion of supply mainly by desalination of sea water in order to reduce water shortage. Some farmers claim that agriculture will collapse if it had to pay the full cost of water production. Some farmers' representatives claim, based on past experience, that any "final" agreement with the Ministry of Finance is just an opening for endless future negotiations and they do not trust this ministry to fulfill its share in the contract in the long run.

In order to understand better the major problems associated with the application of the reform, it is worthwhile to present in brief some of its details, as stated in the appendices attached to the governmental agreement. The annual increase in governmental revenue resulting from the reform denoted by T is given in Appendix B of the contract by[7]:

$$(1) \quad T = \underbrace{\sum_i Q_{ij}(P_{ij} - P_{i0})}_{\substack{\text{Increase in water prices} \\ \text{for agricultural use}}} + \underbrace{\sum_k Q_{kj}(H_{kj} - H_{k0})}_{\substack{\text{Increase in extraction levies} \\ \text{for agricultural use}}},$$

where Q_{ij} and P_{ij} are the **aggregate** quantity and the per unit price of agricultural water of type i (fresh water, saline water, recycled water, etc.) consumed at year j and P_{io} is the current water price (i.e., the pre-reform price). Similarly, Q_{kj} and H_{kj} are the **aggregate** quantity and the per unit extraction levy of groundwater pumped from the k^{th} aquifer and consumed by the agricultural sector at year j , and H_{ko} is the current extraction levy. As mentioned above, under the reform contract, the government is obliged to fully compensate the agricultural sector for the increased costs of water via redistribution of T among farmers according to a predetermined key, specified in Appendix E of the contract.

The key for compensation is based on the actual land use, and it prefers irrigated crops to unirrigated crops. The "*basic-level*" of support (or subsidy), is X NIS per 1 dunam (approximately 0.1 hectares) of land planted for ***irrigated field crops and vegetables***. Areas planted for **irrigated** orchards and for **irrigated** flowers are entitled to a support of $1.5X$ NIS and $1.2X$ NIS per dunam (du), respectively. Support at levels

[6] Although these compensation payments are not required by law, they were often paid to farmers following tedious negotiation processes.

[7] For the sake of clarity and without loss of insight, governmental support of some private water producers is omitted from the equation.

of 0.8X NIS/du, 0.6X NIS/du and 0.5X NIS/du are determined for **unirrigated** orchards **unirrigated** vegetables and **unirrigated** field crops, respectively. Finally, **fallow** land is entitled to a support of 0.2X NIS/du. The above weights are positively correlated with the water consumption of the various crops, but it is not quite clear to us how they were precisely determined. Thus, aggregate compensation, AS, is given by:

$$(2) \quad AS = X(1.5S_1 + 1.2S_2 + S_3 + 0.8S_4 + 0.6S_5 + 0.5S_6 + 0.2S_7)$$

where $\{S_1, S_2, S_3, S_4, S_5, S_6, S_7\}$ represent the aggregate areas planted for irrigated orchards, irrigated flowers, irrigated field-crops plus irrigated vegetables, unirrigated orchards, unirrigated vegetables, unirrigated field crops and fallow land respectively.

At any given year, the specific value of X is determined by the (required) equality between T in equation (1) and AS in equation (2):

$$(3) \quad X = \frac{\sum_i Q_{ij}(P_{ij} - P_{i0}) + \sum_k Q_{kj}(H_{kj} - H_{k0})}{(1.5S_1 + 1.2S_2 + S_3 + 0.8S_4 + 0.6S_5 + 0.5S_6 + 0.2S_7)}.$$

Inspection of equation (3) reveals basic difficulties associated with the application of the reform. For the sake of clarity we present them via three highly simplified examples.

<u>*Example 1*</u>. Assume that the agricultural sector is composed of only three groups of farmers who use only fresh water for irrigation: (a) Farmers in Northern Israel who grow 20,000 du of irrigated orchards and apply 800 m^3 of water per dunam; (b) Farmers in Central Israel who grow 80,000 du of field crops applying 500 m^3 per dunam, and (c) Farmers in the south who grow 300,000 du of unirrigated field crops. Assume also that the application of the reform implies an increase of $P_{ij} - P_{i0} = 0.60$ NIS in prices of fresh water while extraction levies remain unchanged. Under these assumptions:

$$X = \frac{0.6(16,000,000 + 40,000,000)}{(1.5 \cdot 20,000 + 1 \cdot 80,0000 + 0.5 \cdot 300,000)} = 129.23, \text{ (see (3))}.$$

Note that the nominator of the above expression, 33,600,000 NIS, represents the "cake of total revenues" available for distribution among the three groups of farmers. This "cake" will be redistributed to farmers unevenly, and assuming away the adjustments in crop mixes, the results are summarized in the table below:

	Northern Farmers (Irrig. Orchards)	Central Farmers (Irrig. Field-Crops)	Southern Farmers (unirrigated Field Crops)
Increase in cost of Irrigation Water (NIS)	9,600,000 (0.6x16,000,000)	24,000,000 (0.6x40,000,000)	0
Compensation (NIS)	3,876,900 (1.5x20,000x129.3)	10,338,400 (1x80,000x129.23)	19,384,500 (0.5x300,000x129.23)
Total Income Change	**-5, 723,100**	**-13,661,600**	**+19,384,500**

In this simple example farmers of unirrigated crops in the south are the largest winners from the reform, while irrigators in the north and the center are the losers. This example demonstrates the severe limitations of the reform. Firstly, the cost and benefits associated with the reform vary among farmers, with a potential significant discrimination against at least some of the irrigators. In other words, the intention to compensate irrigators for the increase in water prices is not accomplished, and unnecessary tension among the various groups of farmers is very likely. Secondly, since the reform would benefit farmers of unirrigated crops, a wide scale transition of land to unirrigated crops is expected within a few years. Such a transition will adversely affect the national goal of preserving open spaces and natural landscapes (some of the green lungs may turn yellow).

Example 2. Assume now that following the application of the reform, a few farmers in the south might start cultivating 50,000 du of idle or deserted land by applying basic-cultivation. As a result, relatively to example 1, the denominator of equation (3) will increase by 0.2x50,000=10,000, but the total cake in the numerator will not be affected. The value of X will be reduced to 124.44 and the compensation of farmers in the south will increase by 526,900 NIS. At the same time, compensation payments to farmers in the north and in the center will decrease by 143,700 NIS and 383,200 NIS, respectively. In other words, the farmers in the south will enjoy a bigger portion of the same cake, leaving a smaller portion for all the other farmers. The national goal of increasing the area of cultivated land would be at a significant cost to many irrigators.

Example 3. Another possible scenario is that as a result of a reduction in export prices for some field crop products, few farmers in the center will decide (not collectively) to substitute the cultivation of say 20,000 du of irrigated field crops with unirrigated crops. The nominator of (3) will decrease by 6,000,000 NIS (relatively to example 1), but the denominator will decrease as well, and the impact of the above substitution on X won't be clear a priori and dependent on the specific data. In this example the denominator will decrease by (1-0.5)x20,000 =10,000 and therefore X will decrease sharply from 129.23 to 110.4. Thus, with the exception of the farmers who chose to switch from irrigated to unirrigated crops, due to changes in export prices which are exogenous to the Israeli water sector, *ceteris paribus*, all other farmers will become worse-off. Compensation payments to farmers in the north and the south will decline by 1.5x20,000x(129.3-110.4)=567,000NIS and 0.5x300,000x(129.23-110.4)=

2,824,500 NIS, respectively.

Compensation payments for farmers in the center will decline by 2,608,500 NIS.

The last two examples demonstrate an additional difficulty with the forced linkage between aggregate revenues and aggregate compensation. It creates artificial dependencies among farmers and imposes upon them an additional source of uncertainty (i.e., uncertain compensation payments). Since the level of uncertainty involved in agricultural activities is typically high, the negative impact of increased uncertainty on risk-averse farmers is potentially significant. It may also increase tension among various groups of farmers, where some groups are adversely affected by perfectly legitimate decisions made by other groups. Aware of these difficulties, the Ministry of Agriculture intends to support farmers in specific regions who are likely to loose significantly from the application of the reform (e.g., farmers in Beit Shan valley, in Jordan valley and in the Upper Galillee). The budget for the support of specific groups of farmers in specific regions will come from the portion of the reform-associated transfers to this Ministry which will not be redistributed according to the foregoing compensation key.

Additional difficulties with the application of the reform are associated with the dimension of water quality. Although the reform was initiated in order to cope with the severe shortage of potable water, its final version includes an addition of recycled wastewater and of saline water, both classified by quality. The "total cake" of revenues available for redistribution (the nominator of (3)) is the sum of revenues from the various types of water. Since recycled as well as saline effluents are cheaper than fresh water the price gap $(P_{ij} - P_{i0})$ at any specific year (see (1)) for the former is expected to be much smaller than the one for the latter. Thus, the revenues' cake is likely to shrink significantly with the large-scale transition from irrigation with fresh water to irrigation with recycled water which is expected in the near future as an important component of the overall strategy to cope with the current water crisis. This will undoubtedly reduce the incentives of farmers and farmers' representatives to substitute fresh water by recycled effluents on the aggregate level, the reduction in water costs resulting from such a transition will be fully balanced by an equal reduction in compensations.

Moreover, the post-reform price of recycled water will probably be lower than the initial pre-reform price of fresh water. In that case, the price gap $(P_{ij} - P_{i0})$ for farmers who substitute fresh water with recycled water might be negative. In a case of a large-scale transition mentioned above, the revenues' cake, i.e., the source for compensation payments, might be potentially negative. This does not make any sense, but we did not find any mention of this problem in the proposed reform. As stated above, the required linkage between aggregate revenue and aggregate compensation is a potential source of tension among farmers in different regions. The quality-associated problem will also "contribute" to this tension. For example, farmers in the northern and central regions of Israel are likely to oppose the development of an expensive recycling plant designed to substitute fresh water with recycled water to irrigate citrus groves in the south.

Simplicity and low transaction costs are important conditions for a successful reform. Unfortunately, the application of the reform considered here is quite costly and involves many technical difficulties. It requires annual monitoring of cultivated land and a crop-mix at the farm level, as well as an annual monitoring of agricultural water use which varies by qualities. It also requires the adjustment of relevant calculations following the continuous transitions in irrigation from fresh water to recycled effluents. Transferring compensation payments to farmers and negotiating with those who face specific problems[8] on additional compensations, and continuous coordination between the Ministry of Agriculture, the Water Commission and the Ministry of finance involve also high transaction costs. It can also be shown that compensation payments which are dependent on a crop mix cannot implement a first-best social-optimum (Bar-Shira and Finkelshtain, 2000). It seems as if those who formulated the reform were not aware of this source of economic-inefficiency.

3. A Case Study

3.1 Data, Assumptions and Simulated Scenarios

The objective of the case study is to present a *preliminary* evaluation of the quantitative impacts of the proposed reform on Israeli farmers (excluding farmers who specialize in livestock production). The data set used for the empirical analysis is extensive. Based on the division of the country into 24 agricultural regions by the Ministry of Agriculture (See Map 1), we have divided the country into 20 "natural" regions. Then, for each region we have collected commonly used irrigation norms, water-use and land-use data based on 1999 data sets available from the Ministry of Agriculture and the Union of Israeli Farmers. The pre-reform irrigation practices were summarized in a water-use matrix, which includes data on the quantity of irrigation water per dunam, classified by quality (fresh water, saline water, recycled effluents) applied to each one of 100 crops in each of the 20 regions. Similarly, data on pre-reform crop mixes were summarized in a land-use matrix which includes information on the area planted to each one of the 100 crops in each region. Data on commercial yield and pre-reform gross revenues per dunam (in 1999) for each crop in each one of the regions were obtained from the economic department of the Union of Israeli Farmers.

One should recall that currently tiered pricing exists for agricultural water users who pay a reduced price for the first 50% of the quota, a higher price for the next 30% and a full price for the rest of the quota (which is not fully utilized very often). Data on farm-level quotas allocated by the Water Commission and on an actual utilization of these quotas by farmers were collected from the data-bank of the Water Commission. These data were used in the calculation of the average pre-reform price per cubic meter of irrigation water (fresh, recycled and saline) in each one of the 20 regions, namely the values of P_{i0} (see equation 1) at a regional level. The post-reform prices of irrigation water vary by quality and are independent of the location of the farms. Specifically, post-reform prices for fresh water, saline water and recycled waste water are assumed to be equal to 1.46, 1.0, 0.72 NIS/m^3 respectively.

The foregoing large-scale data base was used to evaluate and compare the impacts of the reform on farmers who vary by region and/or the crops they grow.

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[8] For example, farmers who operate fish ponds are likely to lose significantly from the application of the reform. They use an enormous amount of water per unit of land area (i.e., their water costs will increase dramatically), while cultivating relatively a small land area (i.e., their share in the "cake" of revenues will be very small).

Since P_{i0} vary by region, the increase of water prices resulting from the reform vary by location. Let Δ_i^j be the price increase of water type i at the j^{th} region[9] and let q_{mi}^j represent the amount of irrigation water of type i applied to crop m (m=1, ..., 100) grown in the j^{th} region (j=1,...,20). The increase in costs of water applied to one dunam of crop m grown in the j^{th} region is thus equal to $\Delta C_m^j = \sum_i \Delta_i^j q_{mi}^j / S_m^j$ NIS/m^3, where S_m^j is the total area planted for crop m in region j. The per dunam compensation transfer for crop m, denoted by T_m, is dependent on the value of X in equation (3). If for example crop m is an irrigated flower area, then $T_m = 1.2X$. For each crop at each region we calculated the index

$$(4)\quad R_m^j = \frac{T_m - \Delta C_m^j}{GR_m^j}$$

$$= \frac{\text{net impact of the reform (compensation minus increase in water costs), (NIS/du)}}{\text{Gross revenues per dunam planted for crop m at region j, (NIS)}}.$$

Following the calculation of R_m^j (which might be either positive or negative) for each crop at each region, we classified the crops and the irrigation water applied to them to four categories:

(1) "Successful crops" (hereafter **SC**): crops and their associated irrigation water for which $R_m^j > 0$, namely the compensation payment exceeds the increase in water costs; and

(2) – (4) {"Crops under slight threat" (**ST**); "Crops under moderate threat" (**MT**) and "Crops under large threat" (**LT**)} for which $\{-0.05 \le R_m^j < 0$; $-0.10 \le R_m^j < -0.05$; and $R_m^j < -0.10\}$, respectively.

Obviously, the "full-compensation" principle of the reform implies that the aggregate income loss imposed on the threatened crops is completely balanced by the aggregate income gain experienced by the successful crops. Note that all the "winners" from the reform were aggregated into a single category (**SC**) while the "losers," for which compensation payments fall short of the increase in water prices, were subdivided into three categories (**ST**, **MT** and **LT**). In two of the four simulated scenarios presented below we assume that the application of the reform will not affect the area planted for **SC** and **ST**, but some areas previously planted for **MT** and **LT**, the greatest losers, will be substituted with unirrigated crops.[10] The foregoing classification, which is not totally arbitrary, is an outcome of discussions with many

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[9] The average calculated values of Δ_i^j for(fresh water, saline water and recycled waste water are 0.582, 0.225 and 0.254 NIS/m^3, respectively.

[10] Obviously, the area planted for a specific crop is a result of an optimal farm-level land allocation problem that depends on profits per land- unit of this crop and of other competing crops. It also depends on the total land area and the quantity, the quality and the price of water from various sources available for irrigation. Modeling farm level land and water allocations is out of the scope of the current study and is a direction into which our preliminary evaluation of the proposed reform can be profitably extended.

farmers and extension workers. A decline of 0%-to 5% of the gross revenue[11] of a certain agricultural crop does not entail its substitution with other crops. However, a decline larger than 10% might cause a greater loss which will entail the substitution.

A decline of gross revenue between 5% to 10% is considered to be a medium loss. A pertinent comment here is that the ability of the farmers to substitute irrigated crops with unirrigated ones, due to a decline of gross revenue, is limited and entails additional costs. The primary limitations are the availability of financing, knowhow, climatic adaptability and domestic marketability of the crops (the expansion of the area of a certain unirrigated crop might cause a notable decline in its market price).

The assumed scenarios are:

1. Base-case. In this scenario we assume that post-reform levels of all water types allocated to the agricultural sector as well as post-reform crop-mixes in all regions are identical to those which existed in 1999, the pre-reform base-year. In other words, we naively assume here that farmers are passive and do not make any adjustments in land allocation, crop mixes and irrigation practices.

2. Water Substitution. Here we assume the substitution of 253 MCM of fresh water allocated to the agricultural sector with the same amount of recycled effluents, according to the long-term plan of the Planning Department of the Water Commission. The plan is organized on a regional basis in the sense that it takes into account the potential urban and industrial supply and the agricultural demand of recycled effluents in each region. Since we did not find in the reform any indication how to calculate the change in water prices for farmers who substitute fresh water with recycled water, we assume that $\Delta_i^j = 0$ with respect to all the 253 MCM of the substituted water. It is also (naively) assumed that the transition of water sources, as well as the reform itself, will not affect land allocation decisions at the farm-level and that the post-reform crop mixes are identical to those which existed in 1999. Moreover, the per dunam amount of irrigation water applied to a specific crop is assumed to be predetermined and independent of the water type.

3. Crops Substitution. Under this scenario the levels of all the water types available for irrigation are identical to those assumed in the base-case scenario. However, crops for which the value of R_m^j calculated in the base-case scenario was lower than –0.75 (i.e., about half of the crops classified as **MT** and all the crops classifies as **LT**) were substituted with unirrigated crops. Specifically, we assume that irrigated field crops and vegetables[12] were substituted with unirrigated field crops and that irrigated orchards were substituted with unirrigated orchards (50%) and with irrigated field-crops (50%).

4. Substitution of Crops and Water. This scenario combines changes in water consumption with changes in the crop mix. Specifically, the levels of all water

[11] Due to the scarcity of reliable data of the net profit per area unit of the various crops, we have decided to base the classification on gross revenue.

[12] Most of the flower crops are grown in greenhouses, and we assume that that they would not be replaced by unirrigated crops in open fields even if they belong to the group for which R^j_m<-075.

types available for irrigation are assumed to be identical to those in scenario 2 and crops for which the value of R_m^j calculated in scenario 2 was lower than – 0.75, were substituted with unirrigated crops as specified in the previous scenario.

3.2 Results

The above assumptions and classifications of data were used to quantify and compare the potential effects of the proposed reform for the four considered scenarios. Under the base-case scenario, total consumption of irrigation water, 1029 MCM, is composed of 658 MCM, 229 MCM, and 142 MCM of fresh water, recycled effluents, and saline water (including marginal flood water), respectively. The basic-values of compensation payments *X* (see equation (3)), calculated for scenarios 1 to 4 are 169, 117, 138, and 94 NIS per dunam of an irrigated field-crop respectively.
The decrease in the value of *X* under the scenario of water-substitution relative to the basic scenario results only from a shrinkage of the "cake of total revenues" (the nominator of equation (3)[13]) available for distribution. The average level of price increase of recycled water (0.254 NIS/m^3) is 56% lower than the average price increase of fresh water (0.582 NIS/m^3). The impact of the assumed changes in crop mix on the value of *X* is quantified by comparing scenarios 1 and 3 and scenarios 2 and 4. A transition from irrigated to unirrigated crops, which are the largest losers from the reform decreases both the nominator and the denominator of equation (3). The end result is that the basic-compensation per dunam, *X*, is reduced by about 18% or 20% when we shift from scenario 1 to scenario 3 or from scenario 2 to scenario 4. In practice, the value of *X* is unknown to individual farmers while making land allocation and production decisions. The foregoing results indicate that the variability of *X* might be quite large and therefore, the negative impact of the uncertainty associated with the compensation payments on the welfare of risk-averse producers is potentially significant.

Aggregate financial balances are presented in Table 2. The aggregate net income change of irrigated crops is negative under each of the assumed scenarios and is equal exactly to the positive income gained by growers of unirrigated crops. In other words, the reform implies a significant income transfer from growers of irrigated crops to non irrigators. Inspection of Table 2 shows that the level of this transfer declines with the transition to irrigation with recycled effluents.

[Table 2 about here]

The largest "cake of total revenues" which is equal to the farmers' loss from increased water prices, 492 Million NIS, is obtained under the base-case scenario. Changing the crop mix will reduce the cake by 22% relative to the base-case (386 million NIS)). In the absence of crop adjustments, transition to irrigation with recycled effluents will reduce the "cake" by 30% (342 Million NIS). Changes in crop mixes which follow the above transition will reduce the 'cake" further by 34% (265 Million NIS). These results illustrate the significant sensitivity of the aggregate loss from increased water prices to the mix of water types available for irrigation as well as to the choice of crop mix at the

[13] Note that the denominator of equation (3) is not affected by the shift from the base-case scenario to the scenario of "water-substitution."

farm level. Since farmers are supposed to be fully compensated for the increase of water prices, the aggregate farm income is identical under all the foregoing scenarios. However, the *distribution* of income among farmers varying by crop mix and/or cultivation region is quite sensitive to the expected transition from fresh water to recycled effluents and to the expected changes in crop mixes. For example, farmers growing unirrigated crops are likely to lose from the transition to irrigation with recycled effluents, although they consume only negligible amounts of water (if at all). These farmers will gain nothing from the relatively low price of recycled effluents while receiving lower compensation payments, as a result of the reduction in the total cake available for distribution.

The distributions of land area and of water consumption between (1)"successful crops" (**SC** and the other three groups under threat: (2)"slight threat" (**ST**), (3) "moderate threat" (**MT**) and (4) "large threat" (**LT**), are presented in Table 3. Firstly, note that under the base case scenario, 58% of the cultivated land will be allocated to crops for which compensation payments exceed the increase in the water price (**SC**). However, the share of these **SC** crops in total consumption of irrigation water is as low as 17%. About 18% of the water is subject to a moderate threat while 8% are subject to a significant threat.

[Table 3 about here]

These results indicate that unirrigated crops enjoy the lion's share of the *positive net revenues* associated with the reform, which are completely balanced by the aggregate level of *net negative* revenues which accrue to other crops, as shown in Table 2. The land area planted for **LT** and **MT** crops, the greatest losers from the reform, amounts to 14% of the cultivated land while the share of these crops in total water consumption (26%) is almost two times larger. Transition to irrigation with recycled effluents without adjusting crop-mixes yields a significant increase in the area planted for **SC** crops. Following the transition, large areas planted for irrigated crops like citrus and cotton will be irrigated by recycled effluents rather than fresh and expensive water, and as a result will move to the group of **SC** crops. Note however, that the increase in the area planted for **SC** crops is accompanied by a parallel reduction in the area planted for **ST** crops, while the changes in the shares of land and water devoted to the "losers" (i.e., **LT** and **MT** crops) are marginal.[14] In the base-case (scenario 1) as well as in the water substitution case (scenario 2) it is probable that 9% to 10% of the land area (LT + one half of MT) will turn from a year long "green cover" of irrigated orchards and crops to a partially green area in the winter and mostly "yellow cover" in the summer of either dry farming or a total neglect.. This outcome might serve as an estimate of the negative impact of the reform on the landscape and the environment. This is additional to the threat of neglect of cultivable areas which is depicted by basic cultivation.

In scenarios 3 and 4 we assume that farmers react to the reform by substituting all **LT** and some **MT** crops by unirrigated crops. These changes in crop mix are followed by a significant reduction in total water consumption. Substitution of crops and water (scenario 4) results in a reduction of 142 MCM/year (50.7%) allocated to the "threatened" crops **LT** and **MT**. However, the share of the remaining **MT** crops in total water consumption is 3.6, times more than its share in cultivated land under scenario 3,

[14] The composition of the crops in the groups LT and MT in scenario 2 differs from those in scenario 1 (base case)

and 2.3 times more under scenario 4. The results of the case study relate to the effects of the reform in the short run. The analysis of the dynamics of the change in the long run is out of the scope of the current study. However, it is feasible to assume that the change to unirrigated farming in a certain year will entail a diminution of the revenue cake which is destined for distribution in the following year. The effect of the diminution will be that additional irrigated crops will join the threatened groups LT and MT , and some of them will be substituted by unirrigated crops later on and cause a further loss of revenue. Such a dynamic process might initiate instability in the agricultural production system, which might eventually lead to a partial desertion of farmers from agriculture.

As mentioned above, the impacts of the reform vary widely by region. Net income changes at a regional level as well as the percentage of irrigation water allocated to the most threatened crops (**LT** and **MT**) are presented in Table 4. The table illustrates the spatial variability of the impacts. The regions in which more than forty percent of the water are threatened crops (i.e., allocated to **MT** and **LT**) under the base-case scenario include the Hula Valley, Upper Galillee, Western Galillee, Kinerot Basin, Beit Shean valley, Gilboa-Harod, Jordan Valley, Lower Galillee, Hills of Nazareth and Arava. An inspection of Map 1 reveals that some of these regions are located in the northern part of the country while others are located along the eastern part, from the Kinerot basin in the north to the Arava in the south. These regions are characterized by a relatively high water consumption per unit of land area and a supply of water at a relatively low pre-reform price by private producers (rather than Mekorot) such as regional cooperatives and private well operators.

[Table 4 about here]

For the purpose of a representation of the effect of the reform on three regions, the 1st in the North, the 2nd in the Center, and the 3rd in the South:

(i) The Hula valley: it is located in the peripheral north-east part of Israel, close to the sources of the river Jordan (which is the main source of water of lake Galilee (i.e. Kineret). The agricultural production is based on irrigation with fresh water. The sparse population emits only small quantities of waste water, and the resulting amount of recycled effluents is too small to substitute most of the fresh water. Most of the irrigated crops (primarily cotton and field crops) consume large quantities. The outcome is that the net income change under the base case is negative (-9.9 million NIS/year), and 42% of the water is used by threatened crops. The substitution by recycled effluents (scenario 2) anywhere entails a significant reduction of the revenue cake that will be available for distribution. However, due to the fact that in this region the quantity of recycled effluents is small and a substitution of fresh water is ineffectual, the loss from the reform will grow 15.8 million NIS/year and the quantity of water that is intended for threatened crops is 83% of the total. If the farmers in the region will react by a crop substitution with unirrigated ones from groups LT and one half of MT, the loss will be diminished by the reform (see: scenario 4) to an equal level with the one in the base case.

(ii) Rehovot: It is located in the center of Israel, south of Tel Aviv. The agricultural major crops are orchards (especially citrus), field crops and green houses. The region is adjacent to the largest metropolitan areas and recycled effluents are available for it. The irrigation is performed with both fresh water and recycled effluents. Under the best case scenario the benefits to the region from the reform is 3.4 million NIS/year, and only 3% of the water is to threatened crops of the MT and LT groups. The substitution with recycled water improves the revenue position only slightly, due to the fact that it has already realized its potential of the substitution even before the reform. However, though the aggregate profit of the region increases due to the substitution, the percent of water to threatened crops also increases from 3% to 11%. This increase is related to irrigated crops with fresh water. The cost of water for irrigation for theses crops is not affected by the substitution, but the compensation given to them declines due to the substitution. Due to the reform the region loses under scenarios 2 and 3. In case that threatened crops all over the country will be substituted with unirrigated crops, the revenue cake which is destined for distribution will be diminished significantly, and with it also the support given to the farmers of Rehovot. The final outcome, in terms of regional data is a negative change in net income.

(iii) <u>Negev:</u> It is the largest region in southern Israel populated sparsely, but the recycled effluents of the metropolitan area of Tel Aviv are transported to it through the conveyance system of the Shafdan. The region receives also a supply of fresh water which is transported through the NWC system. Despite that, most of the tillable area is planted for unirrigated field crops (mostly wheat). Due to the major share of unirrigated crops of the sizable tillable area, this region is the largest beneficiary of the reform. The additional net income ranges between 14 to 26 million NIS/year.

Table 5 presents the data of the outcome of the reform on the major crops. The decision

[Table 5 about here]

about the total quantity of water which is allocated to a certain crop is the outcome of its norm of need and the size of the planted area for it. It also depends on the geographical location. Generally, the further south or east is the location of the planted area the larger is the water requirements of a crop. The crops also differ in their potential irrigability with recycled water, The plantation branch is the largest loser, except for crops such as table and oil olives which consume smaller quantities of water per area unit relatively to the other crops. The income loss is for all the prominent types: subtropical crops (mango and avocado), table and wine grapes, dates, bananas, peaches and other deciduous trees. The effect on banana plantations stands out because its phenological characteristics prohibit its irrigation with recycled effluents. The conclusion is that the banana area will decline by 75% due to the reform mainly in the Kinerot valley. The citrus crop, however, is an exception to the foregoing conclusion because it is expected to gain from the reform, due to the fact that it can be irrigated with reclaimed water.

The flower branch also loses somewhat due to the reform, but its areas will not decline due to the large revenue from it relatively to all other plantation crops. Thus, there will not be any reduction in the planted area for it. The damage to the vegetable branch is most notable. The degree of threat is high such that its area might decline by

about 25%. It is quite feasible that due to its decline the prices of vegetables will rise in the domestic market (a rise that was not included in the case study), and the damage to the growers might be smaller. The potato branch is an exception to the foregoing conclusion because the effect of the reform on it is only a slight one if any at all.
It is quite obvious that the unirrigated crops will gain from the reform due to the fact that they will receive support payments and will not be affected by the rise of water prices.

4. Summary and Concluding Remarks

Decisions on water policies and pricing in Israel are made at the political arena, and are significantly affected by the pressure of a well organized agricultural lobby. Unfortunately, the continuing success of this lobby is one of the major reasons for the current water crisis, whose main features are shortage of fresh water and steadily increasing deficits, poor and declining ground water quality and pollution of most of the streams. It seems that since 2001, policy makers, as well as many farmers, are beginning to realize that raising water prices for the agricultural sector is inevitable. It will lower the demand for water for agriculture and will affect agricultural activities. Indeed, cancellation of the current tier-pricing system of water for agriculture and a gradual increase of its price are the central building blocks of the reform in agricultural water pricing initiated by the Minister of Agriculture. Since water is an important input in agricultural production, the suggested price increase may have significant adverse consequences for the agricultural sector, which is considered by the government as an enterprise of a national importance that exceeds its contribution to GNP via food production. The contribution of this sector to national security and the environmental and social landscapes justifies governmental support. This, coupled with the government efforts to overcome farmers' objection to the reform and some other of the foregoing conclusions are the major reasons for the other central building-block of the reform, which is a full compensation of farmers for their loss due to the increase of water prices.

In principle, the general idea of the reform to base the allocation of water on an efficient price system, and at the same time to preserve the vitality of the agricultural sector, can be partially justified from the point of view of the economy at large. Unfortunately, the details of the reform, especially the forced linkage between the aggregate increase in costs of irrigation water and the aggregate compensation payments to farmers, imply many difficulties. The costs and benefits associated with the reform vary among farmers with a potential significant discrimination against some of them. This variability is likely to yield unnecessary tension among various groups of farmers in various regions of the country. The linkage between costs and benefits creates artificial dependencies among farmers and imposes upon them an additional source of uncertainty (namely, uncertain compensation payments) with a negative effect on the welfare of risk averse farmers. Since the reform will benefit unirrigated farmers significantly, one may expect within a few years a large scale transition to unirrigated crops. Such a transition will adversely affect the national goal of preserving open spaces and natural landscapes. Additional difficulties with the application of the reform are associated with the dimension of water quality. The "cake of revenues" available for distribution among farmers is likely to shrink significantly with the large-scale transition from irrigation with fresh water to irrigation with recycled effluents, as expected in the near future. This may reduce the incentives of many farmers and farmers' representatives to comply with the governmental plan to substitute fresh water with recycled effluents, a plan which is an important component of the overall public strategy to cope with the current severe water crisis. In addition to the foregoing difficulties, it seems as if the application of the reform is quite costly and involves numerous technical difficulties such as annual monitoring of activities at the farm level, negotiations with farmers having specific problems and a continuous coordination among the key public decision makers in the water economy.

A stated principle of the reform is that the prices of water of a given quality for agriculture are to be equated with the water prices for use by the industrial and household sectors. It might have significant and far reaching influences not only on the agricultural sector but also on the whole water economy. As stated above, due to the crisis of the water supply, Israel enters an epoch of a massive desalination of seawater. Effective allocation of water requires equating the price of fresh water to the marginal cost of desalination in the long run (inclusive of the conveyance cost). But the Israeli agricultural sector can not withstand such high prices, and an equilibration of water prices might be feasible only if the prices of water for urban use will be lower than the marginal cost of desalination. The designation of lower prices will affect the structure of the water economy. If the prices facing the municipal authorities will be equated with the marginal cost of desalination (inclusive of the conveyance cost), many of those authorities, especially the ones located at the coastal plain, would prefer to desalinate seawater independently and connect the desalination plant directly to the municipal conveyance system (an act that would reduce the conveyance cost and therefore the price of water). However, if desalinated water would be supplied to the municipalities by Mekorot for relatively lower prices through the national conveyance system, it would not be viable for them to build desalination plants on their own. In this case, the government is the authority that will issue contracts to build the desalination plants (which is what actually occurs now) that will be connected to the national conveyance system which supplies the municipalities. The outcome of this will be an increased centralization of the water economy due to a growing dependence on government owned companies, which is against the stated principles by the government of the needed greater privatization and decentralization of the water economy.

Although the first of January 2002 was determined by the Ministry of Agriculture, the Ministry of Finance and the Ministry of Infrastructure as a starting date of the reform, it has not been applied yet. It still requires the approval of the government as a whole and of the Finance Committee of the Kneset (The Israeli Parliament). The Minister of Agriculture is threatening to resign, if it will not be applied soon, The general director of the Prime minister's office nominated a new committee (chaired by one of the authors of this manuscript) to re-evaluate the whole issue of agricultural water pricing before applying the reform. The main reasons for the delay are the strong objection of some groups of farmers in some regions who are expected to lose significantly and an awareness of the difficulties considered here by some policy makers

The case study considered here is preliminary, since it involves many simplified and ad-hoc assumptions, and its results should be treated with care. Specifically, the classification of crops and irrigation water to categories of losers and winners, as well as the assumed responses of farmers via change of crop mix are arbitrary, and the negative impact of increased water prices on the total agricultural demand for water is ignored. The empirical analysis is highly aggregated and a potential adjustment of prices of crops resulting from aggregate changes in crop-mixes is assumed away. However, we strongly believe that the analysis provides proximate quantitative answers to core questions associated with the application of the proposed reform. The analysis considered here can be used as a central building block in an extended analysis, which will be based on more pertinent assumptions. It will model more accurately the impacts of changes in water policies on land allocation and on irrigation decisions at the farm level.

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Table 1: **General Water Balance (MCM/Year)**.
Sources: New Master Plan for the Water Economy of Israel, January 2002; Israeli Geological Service, Hydrological Report, 2000; and data from the Consumption Division of the Israel Water Commission.

	Normal year (1998)	**Drought year (2002 estimate)**	**Future average year (2010)**
Demand by sector:			
Domestic	694 (31%)	680 (39%)	875 (36%)
Industrial	129 (6%)	131 (8%)	167 (7%)
Agricultural	1326 (59%)	837 (48%)	1165 (48%)
Jordan & PA	98 (4%)	85 (5%)	160 (7%)
Environment	4	2	40 (2%)
Total	2251 (100%)	1735 (100%)	2407 (100%)
Allocation by water type:			
Freshwater	1749 (78%)	1248 (72%)	1709 (71%)
Reclaimed	276 (12%)	298 (17%)	509 (21%)
Saline	226 (10%)	189 (11%)	189 (8%)
Total	2251 (100%)	1735 (100%)	2407 (100%)
Supply:			
Aquifers + Surface Water (including saline)	1975 (88%)	1432 (82.5%)	1398 (60%)
Desalination	-	5 (0.5%)	500 (19%)
Recycled	276 (12%)	298 (17%)	509 (21%)
Total	2251 (100%)	1735 (100%)	2407 (100%)

Notes: 1998 serves as the representative year for the 1990's decade.
1999 to 2001 were drought years with minimal precipitation.
2002 is an average rainfall year, but the hydrological crisis is very evident because of the paucity of the aquifer reserves and the severity of salinity, due to over-pumping during the previous drought years. The year 1999 (drought year) had a balance similar to that of 1998.In general, the shortage is not only a function of the precipitation level of a specific year, but mostly, a consequence of the pumping policy for the aquifers in past years.

Table 2: Aggregate Financial Balance (Million NIS/Year)

		(1) Base-Case	(2) Water-Substitution	(3) Crops-Substitution	(4) Substitution of Crops And water
Irrigated-Crops	Loss from Increased Water Costs	-478	-332	-372	-255
	Compensation	359	250	261	182
	Net Change	**-119**	**-82**	**-111**	**-73**
Unirrigated Crops	Loss from Increased Water Costs	-14	-10	-14	-10
	Compensation	133	92	125	83
	Net Change	**119**	**82**	**111**	**73**
Total Changes	Loss from Increased Water costs	-492	-342	-386	-265
	Compensation	492	342	386	265
	Net Change	**0**	**0**	**0**	**0**

Table 3. Country Level Distribution of Land Area (Thousands of Dunams) and Water Consumption(MCM) According to the Categories SC, ST,MT, and LT

		(1) Base-Case		(2) Water-Substitution		(3) Crops-Substitution		(4) Substitution of crops and water	
Land	Category	%	Thous. du	%	Thous. du	%	Thous. du	%	Thous. du
	LT	3%	91	3%	105	0%	0	0%	0
	MT	11%	343	10%	317	3.5%	113	6.4%	205
	ST	29%	918	16%	510	27.6%	884	16.2%	519
	SC	58%	1,853	71%	2,273	68.9%	2,208	77.4%	2,481
	Total	100%	3,205	100%	3,205	100%	3,205	100%	3,205

		(1) Base-Case		(2) Water-Substitution		(3) Crops-Substitution		(4) Substitution of crops and water	
Water	Category	%	MCM	%	MCM	%	MCM	%	MCM
	LT	8%	84	7%	70	0%	0	0%	0
	MT	18%	186	17%	178	12%	102	15%	128
	ST	57%	583	34%	348	62%	530	36%	319
	SC	17%	177	42%	432	26%	226	49%	434
	Total	100%	1,029	100%	1,029	100%	858	100%	881

Table 4: **Regional Effects**

Region	Percentage of LT + MT Water (%)				Net Income change (Millions NIS/Year)			
	Base	Water-Subs.	Crops -Subs.	Crops+ Water Subs.	Base	Water -Subs.	Crops -Subs.	Crops+ Water Subs.
1. Golan	19%	28%	0%	0%	-5.7	-11.4	6.6	-7.3
2.Hula-Valley	42%	83%	0%	58%	-9.9	-15.8	-6.4	-10.2
3.Galillee heights	26%	25%	10%	76%	-5.3	-8.4	-5.2	-7.0
4.Upper Galillee	42%	42%	36%	0%	-1.6	-2.4	-1.8	-1.5
5.Western Galillee	56%	22%	66%	29%	2.6	6.9	3.7	0.2
6. Kinarot Basin	99%	82%	45%	31%	-15.4	-15.6	-0.7	-0.3
7. Beit Shean Vall.	73%	98%	0%	83%	-8.4	-13.6	0.2	-3.6
8. Gilboa-Harod	43%	45%	28%	20%	2.1	-0.8	0.9	0.1
9.Jordan Valley	72%	56%	64%	41%	-8.2	-7.9	-7.1	-4.7
10. Lower galillee	70%	44%	0%	0%	5.9	6.2	6.8	7.3
11.Jezreel Valley	30%	0%	9%	4%	13.4	13.4	8.1	9.7
12.Hill of Nazereth	55%	4%	9%	4%	7.2	5.4	7.1	4.2
13.Hadera	15%	15%	15%	7%	-0.8	2.8	-7.9	-2.0
14.Raanana	0%	0%	0%	0%	-4.9	2.7	-9.9	-1.6
15.Rehovot	3%	11%	3%	11%	3.4	4.9	-6.1	-1.8
16.Jerusalem Mout.	18%	0%	0%	0%	8.3	6.1	6.9	3.8
17. Lacish	5%	36%	2%	12%	-0.6	-1.0	2.3	-0.6
18. Besor	5%	0%	5%	0%		6.5	-7.5	2.3
19. Negev	4%	0%	6%	0%	21.6	26.0	13.7	17.9
20. Arava	57%	19%	32%	19%	-9.6	-4.1	-3.7	-4.9
Total	**26%**	**24%**	**10%**	**15%**	**0**	**0**	**0**	**0**

Table 5: Effects of the Reform on Major Crops

	Percentage of LT + MT Water (%)				Thousands dunams		Net Income change (Millions NIS/Year)			
	Base	Wat.-Sub.	Crop. Sub.	Crop+ Wat. Sub.	Base	Crop+ Wat. Sub.	Base	Wat.-Sub.	Crop. Sub.	Crop+ Wat. Sub.
Flowers	0%	0%	0%	0%	52	52	-21	-18	-17.5	-21
Citrus	5%	3%	5%	3%	253	253	-17	15	15.3	7
Vegetables	30%	28%	30%	3%	118	160	-25	-19	-18.6	-10
Cotton	32%	8%	32%	0%	146	157	0	8	7.7	7
Unirr.Field -Crops	0%	0%	0%	0%	1,359	1,231	96	67	67	59
[illegible]atoes	0%	0%	0%	0%	107	107	-8	0	-0.2	-3
Spices	NA	NA	NA	NA	4	4	0	0	-0.1	0
Irrig. Field -crops	34%	22%	34%	5%	614	652	30	26	26.4	18
Unirr. Plantations	0%	0%	0%	0%	218	177	23	15	15	13
Sub-Trop. Plantations	84%	79%	84%	49%	52	89	-20	-22	-21.9	-9
Grapes	32%	32%	32%	0%	29	35	-3	-5	-5.1	-3
Dates	98%	32%	98%	98%	15	18	-9	-11	-10.8	-9
Bananas	49%	98%	49%	0%	17	26	-15	-17	-16.7	-10
Deciduous Plantations	1%	28%	1%	43%	157	158	-22	-32	-32.4	-36
Other Plantations	52%	53%	52%	43%	62	83	-7	-8	-7.9	-4
Total	26%	24%	26%	15%	3,205	3,205	0	0	0	0

Map 1 : Agricultural Areas