CHAPTER 10

The Water Economy of Israel

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The discussion in this essay is influenced by developments that have brought the water sector to its current condition and by the public debate on water in Israel that is overshadowed nowadays by the acute crisis the country is experiencing. Water users are facing recurring shortages and supply to agriculture was cut. One may easily conclude that the sector is in shambles. My review of the issues has led to a different perspective. True, there was neglect, a lot should be repaired, and attention must be paid to changing circumstances; nevertheless the fundamental structure of the sector is sound, a basis for reforms exists, and the water economy can be expected to fulfill its functions, now and in the future.

General Features

Israel is a small and narrow country half of whose area is desert. Precipitation, which occurs mainly in the winter, averages more than 700 mm per year in the north and less than 35 mm in the southern tip of the country. The core functions of the water sector have been to store water from winter to summer and from rainy to dry years, and to carry water from the north to the center and the south. With expanding population and growing urbanization, sewage treatment and recycled water are taking center stage.

Fresh water is stored in Lake Kinneret (Lake Tiberias, figure 10.1) and in several groundwater reservoirs, the two largest being the Mountain Aquifer and the Coastal Aquifer. The Mountain Aquifer is located mostly under the West Bank from a point south of Nazareth to Beer Sheva. The Coastal Aquifer stretches along the Mediterranean Sea from a point south of Haifa to the southern tip of the Gaza Strip. The National Water Carrier

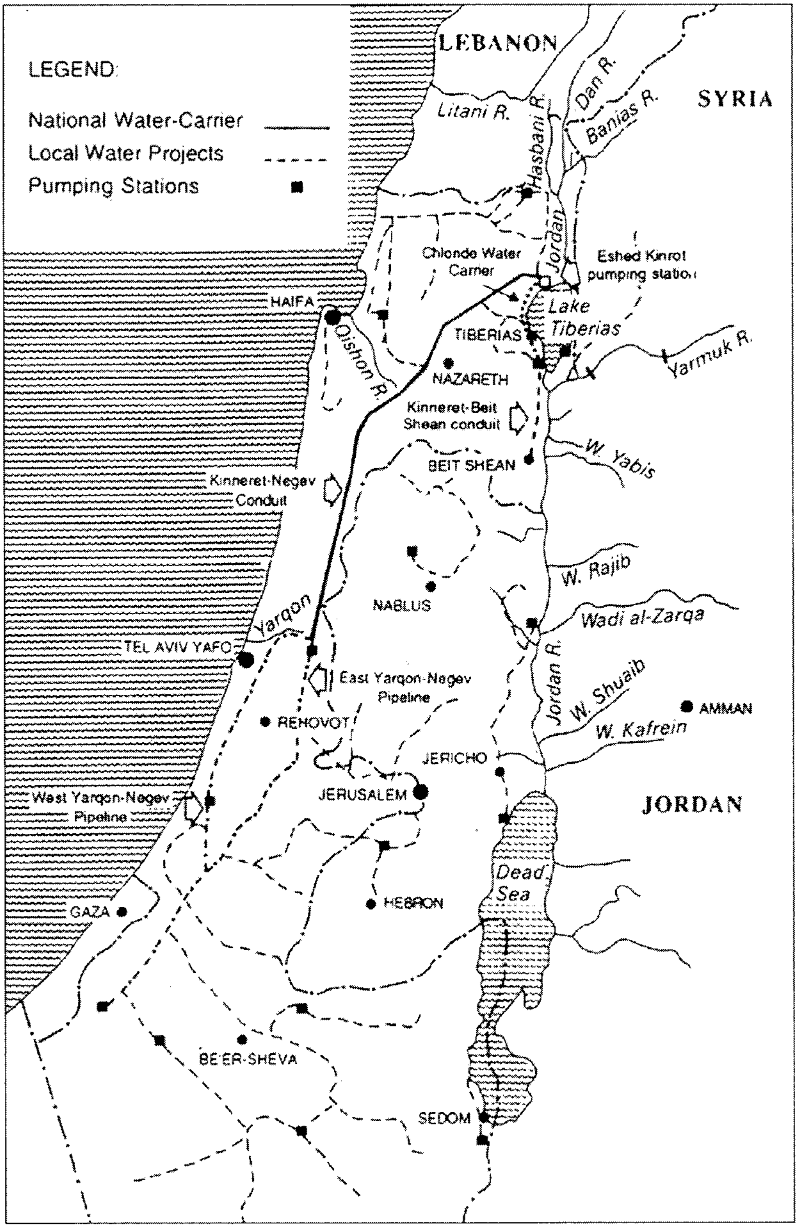

Figure 10.1 A Map of Israel and the National Water Carrier network.
Source: Nurit Kliot, *Water Resources and Conflicts in the Middle East* (London: Routledge, 1994). Political borders are marked in the map by broken dotted lines. The major water arteries are marked by solid lines, the minor arteries by broken lines.

is a system of conduits running west and south from Lake Kinneret and connecting most of the sources and users of water in the country. Two-thirds of the water in Israel is supplied by the largest utility, Mekorot Water Co., Ltd. (hereafter Mekorot), and the company also operates the National Water Carrier. The other suppliers are private well owners, municipalities, and regional cooperatives. Municipalities are required to collect and treat their sewage and several cities have cooperative projects with agricultural interests in their vicinity.

As natural resources, the water reservoirs are common pools. Under open access, individuals will behave as "free riders": they will pump water so long as it is beneficial for their own use disregarding the detrimental effect that their pumping has on other users of the reservoirs (for example, by lowering water levels or drawing in salty ocean water). The common resource will thus be depleted.[1] In addition, suppliers, particularly Mekorot, are monopolies. These features call for government intervention. Consequently, by law, all water sources in the country are publicly owned; there is no private ownership of water. The Water Commissioner is responsible for the utilization and the sustainability of the resources. The law requires measurement of all uses of water. This means that wells and pumps are monitored and consumers – households, manufacturers, farmers, and others – pay according to the quantity they use.

The "safe yield" water supply from natural sources is estimated as 1,550 Mm^3/yr [million m^3 per year].[2] Added to this quantity are 270 Mm^3 of recycled water. This source has been growing in importance in recent years. For example, most of the irrigation water in the western Negev[3] is provided by recycled water from the metropolitan area of Tel Aviv. The forecast is that by the year 2020, Israel will utilize 830 Mm^3 of recycled water per year. The first comparatively large (100 Mm^3 per year) desalination plant on the coast of the Mediterranean Sea south of Tel Aviv commenced production in 2004 and preparations are under way for the installation of additional capacity. Consumption in households and industry was 740 Mm^3 in 2001 and is increasing with population growth. By a government decision, agriculture will be provided with 1,160 Mm^3 per year from all sources with allocation of recycled water gradually expanding until it covers 50% of the supply.

Resources are limited and their development is expensive; population growth has surpassed water supply over the last half-century, and the amount available per person has declined. However, as figure 10.2 demonstrates, per-capita consumption in households and industry has remained essentially constant, while per-person water available for agriculture is today less than half the volume of the 1960s. Despite the reduction, agricultural production per capita is today more than 150% of the quantity produced 40 years ago. By these numbers, water productivity in agriculture has increased three-fold over the period.

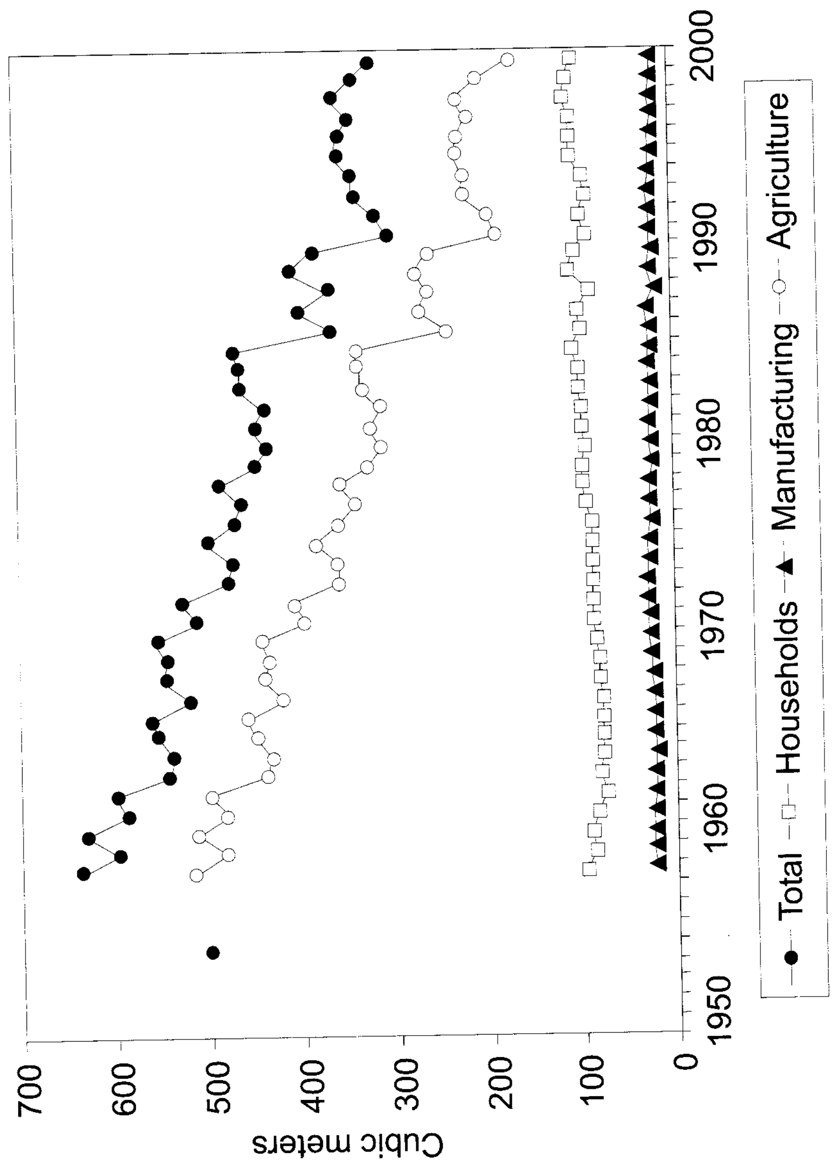

Figure 10.2 Water Utilization (m³ per year) in Israel (per capita) (water use divided by population in the country).
Source: State of Israel, Central Bureau of Statistics, *Statistical Abstract of Israel*, various years.

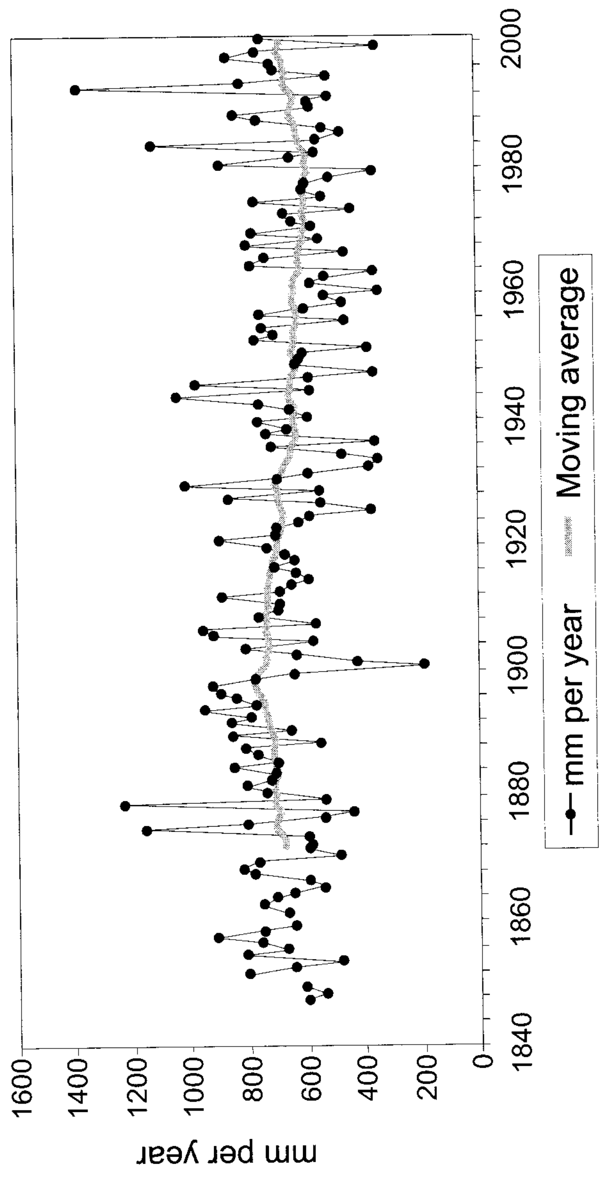

Figure 10.3 Rain in Nablus, mm per year and 25 year, moving average.
Source: Jacob Lomes and Nona Rinborg, Reconstruction of Seasonal Rain in Nablus, 1870–1990, *Water and Irrigation*, 313: 26–29, 1992 (in Hebrew) and data received from The Meteorological Service of Israel. By evidence from other locations, the extremely low value for 1900 is an error.

Water potential and safe yields are generally stated in terms of average use. Precipitation varies from year to year as can be seen from the 150-year record for Nablus[4] in figure 10.3. But not only does annual rain change, long-term averages also vary. The heavy line in the diagram depicts 25-year means; the average for the last quarter of the nineteenth century was more than 20% higher than the lowest value that the heavy line hit – the average for the 25-year period prior to 1979. With varying rain, replenishment of the reservoirs is not stable. Moreover, the changes in the moving average indicate that water potential may also change from one period to another.

There is a tradeoff between average supply and its reliability. With a policy of regular extraction of large quantities of water, reservoirs are often low and, since replenishment varies, reliable supply cannot be maintained. This truism was brought home twice in the last 15 years, once in 1990–91 and again in 1999–2002. Israel is now facing an acute water crisis into which the country slid when several dry years followed a period of over-utilization. The crisis caused a public outcry and even panic. And indeed, in November 2001, the water level in the Lake Kinneret reached its lowest level in known history[5] and the aquifers show clear signs of over-drafting; but the overall picture is not as bad as the public may have been led to believe.

Comprehensive Water Balance

Drawing on Tony Allan,[6] who coined the term "virtual" for water imbedded in traded food, table 10.1 presents a rough calculation of the comprehensive water balance of Israel. The information in the table is based on accepted "norms," not actual data. The norm for average water needs for food production, including rain, is 1000 m^3 per person per year (this is a global average, not specific to Israel). Hence, for a population of 6.5 million, water needed for food production is 6,500 Mm^3 a year. Adding normative values for households and industry, total needs are 7,300 Mm^3 per year. Rain falling on 400,000 hectares of cultivated land contributes 1,600 Mm^3 to the balance, 2,000 Mm^3 come from natural and other sources, and my rough estimate is that 500 Mm^3 of virtual water are withdrawn in exports. The available supply is 3,100 Mm^3. The gap between the needs and available water is 4,200 Mm^3 per year.

The gap is closed by imported food, grain in particular. Israel imports 3.8 million tons of grain a year. On average, again globally, it takes 1 m^3 of water to produce 1 kg of grain; the imported grain is therefore equivalent to 3,800 Mm^3 per year. For the remainder, and to close the balance, I added other imports – sugar, beef, cereals, dried fruits, and others – although I do not know the water content of these products.

The water balance of table 10.1 is just a first approximation and my estimate of local availability was built on optimistic assumptions, but the general picture is clear: water from local sources covers less than 50% of the needs of the country. Moreover, local sources cover only 35% of the water used in food production for the domestic markets. Local water is not crucial for food supply to the population of Israel. This does not mean that we can do without water; it means that a reduction, even a sharp reduction, of allocation to agriculture will not risk the food situation of the country. The crisis is painful but it need not cause panic.

Table 10.1 The comprehensive water balance in Israel (in Mm^3 per year) (see text for details)

Needs	*Mm^3 per yr*
Food (1000 m^3 per person per year)	6,500
Households (100)	650
Industry	150
Total Needs	7,300
Availability	
In the soil (400,000 h × 400 mm)	1,600
Production (including recycled)	2,000
Less: Export	–500
Total Available	4,200
Gap (needs minus availability)	3,100
Import	
Grain (food, feed and oil, 3.8 million t/yr)	3,800
Other	400
Total Import	4,200

Table 10.1 reveals the dependency of Israel on food trade (the country also depends on trade in industrial goods and services). It was pointed out by Allan that this dependency is a common attribute of all the countries in the Middle East; without imports we could not have fed our populations. Starving people would have then fought ceaselessly over every drop of water. Here is globalization contributing to peace.

Hydropolitics

Government intervention in the management of water is a necessary consequence of the common pool features of the resources and the monopoly position of the suppliers. Once the government is involved, in any issue, interest groups arise in an attempt to change public policies in their favor.[7] Lobbies are particularly prevalent in democracies but political pressure can be found everywhere. The two strongest groups in the water sector, the farmers and the workers of Mekorot, have different interests and attempt to affect different aspects of policy. (The "greens" form the third group. They are growing in strength but their effect is still marginal.)

The main interest of the farmers is to get large supplies of water at the lowest possible price. Water is an important input in agriculture and many farmers enthusiastically support their representatives in the political arena. The agricultural lobby is therefore well-organized and acts vigorously in advancing its case. It is said in Israel that a politician stands firm when pushed on all sides.[8] But, as water is not an economically important item in the budget of households or in the cost of manufacturing, the farmers do not face strong opposition and they have succeeded in tilting the policy in their favor. It must be added, however, that the farm lobby, although still alive and supported in high places, has lost some of its power in the last decade or two. The loss can be attributed to the decline of the share of agricultural output and employment in the national economy, as industry and services expanded, and perhaps also to the growing intuitive comprehension, by the public, of the realities presented in table 10.1.

Comparatively low prices and large quantities of water allocated to agriculture result in two major consequences: (a) the reservoirs are depleted and supply is put at risk; and (b) economic waste is created in the sense that water is used in products that cannot cover the real cost of this factor of production. This is particularly true for "virtual" water in some of the exports; citrus is an example.

Interest groups, farmers among them, do not adopt the point of view of the economy at large – they act as "free riders". The farm lobby advocates expensive expansion of supply to overcome shortage and it is quick to find patriotic justifications for subsidies to agriculture. The ability of a lobby to affect policy, the power of the interest group, depends on the environment in which it operates. Consider a region drawing water from a river and exhausting the flow, both in regular and in dry years. There is no more water than what the river carries and, as much as it may try, a political lobby cannot pressure the authorities to increase allocation. The situation is different when supply is, as in Israel, from reservoirs. The total amount of water stored in the coastal aquifer, to take one example, is estimated to be 18,000 Mm^3; safe yield is 250–300 Mm^3 per year, less than 2% of the storage. Over-drafting accelerates the accumulation of salts in the aquifer, but there is no physical constraint to tie the hand of the Water Commissioner when he, willingly or reluctantly, yields to pressure for more water.[9]

Originally, the Water Commission operated from the Ministry of

Agriculture and was deemed to be under the influence of agricultural interests. The Water Commission was moved, several years ago, to the Ministry of National Infrastructures. The change was not motivated by efficiency considerations but it was welcomed by many observers of the water sector. Their happiness was premature. The Minister of National Infrastructures at the time, Ariel Sharon, was a farmer; he even owned the largest private farm in the country, and he appointed another farmer, Meir Ben-Meir, as the Water Commissioner. In my judgment, it was the pro-farm policy of this commissioner – a myopic pro-farm policy – that paved the way for the current crisis.

The workers of Mekorot form the other interest group in the water sector. Their power stems from their organization – 2,200 men and women under a strong union leadership – but especially from their control of the supply: their hand is on the tap. The first interest of the workers is income; their salaries are among the highest in the country. Inflated salaries increase the cost of water, but perhaps more costly is the support the workers give to the monopolistic power of the company. As a large monopoly, Mekorot may build expensive projects and secure employment for its workforce, safely assuming that all costs will eventually be covered. The government has been trying, for more than 10 years, to reform the company, to separate its operations into several relatively small units, and make it into a public utility, independent and responsible for its finance. The workers opposed the reform and, although it did have some important effects on the economic functioning of the company, the reform was only partly successful. An indicator of the remaining strength of Mekorot is that the present Water Commissioner (in office since mid-2000) was the chief engineer of Mekorot before assuming his position as a public servant. (Meanwhile, the former Minister of National Infrastructures became the Prime Minister and has been using his top position to block austerity moves suggested by the new Water Commissioner.)

Allocation

There are two major allocation problems in the water sector: (a) allocation of extraction – where, when, and how much to pump; and (b) allocation of water for utilization and consumption. The two problems are distinct, although the law obscures the distinction.

The criterion for extraction of water is sustainability of the resource. The role of the Water Commissioner is to guard the long-term stability of the quantity and quality of water. Fulfilling this role may require decisions on each source and well separately, depending on local hydro-geological circumstances. Accordingly, the law specifies that water may be extracted only under a license from the Water Commissioner.

The criterion for the allocation of water for consumption and utilization is efficiency, that is, the maximization of economic welfare from the use of water. Two management instruments are in use: prices and quotas. Households and most manufacturers can purchase from Mekorot all their demand at the established prices. Water in agriculture is allocated by quota and, in addition, farmers who purchase water[10] pay Mekorot or the regional suppliers. In principle, quotas are reallocated every year; in practice, they have not changed much in the last several decades (marginal changes were made and will be discussed below).

Prices reflect cost. Two major factors have affected cost of water in Israel: one has been the shift from relatively inexpensive to higher cost systems and the other has been the rise in the world price of energy since 1974. I start with a sketch of the historical development of cost and demand in figure 10.4. The diagram is drawn in today's prices; that is, it does not reflect past changes in the price of energy. The stepwise increasing graph traces my assessment of the cost of water: cost of local supply is 12 US cents per m^3, average cost of water supplied via the National Water Carrier is 35 cents per m^3, and cost of desalination is estimated to be 60 cents per m^3.[11] The graph also traces historical changes of costs in the three epochs of the development of the water economy of Israel. In the 1950s and early 1960s Israel was in the epoch of local supply; the National Water Carrier opened in 1964 a new epoch of expansion, at a higher cost, from 600 Mm^3 to 1,550 Mm^3 a year. The period beginning from 2004 is the epoch of desalination.

The lines marked 1960, 1970, 2003, and 2010 represent demand in these years. In 1960, a few years after the establishment of the State of Israel, irrigation was not widely practiced and the demand for water was modest. When the cost to users was 12 cents the quantity used was less than the potential supply of the time. But it has expanded. In the early years the expansion was generally due to the introduction of irrigation into areas of dry farming, and more recently, when the expansion of agriculture has been slower, most of the increased demand is in urban areas, due to growth of population. As plotted, the demand of 2003 put Israel in the transition period, between the epoch of the National Water Carrier and that of desalination. We shall return below to some of the implications of the conceptual framework of figure 10.4.

The government sets the price that the controlled monopoly Mekorot may charge; essentially it is the same price for all users in agriculture. Regional suppliers – most of them cooperatives – charge to cover cost. In the past, the Water Commission operated an Equalization Fund: well owners and other low-cost suppliers (who had access to local sources of water) contributed to the fund, high-cost operators were compensated. Since Mekorot was the major provider of water to remote and hilly areas, the company received the lion's share of the accumulated funds.

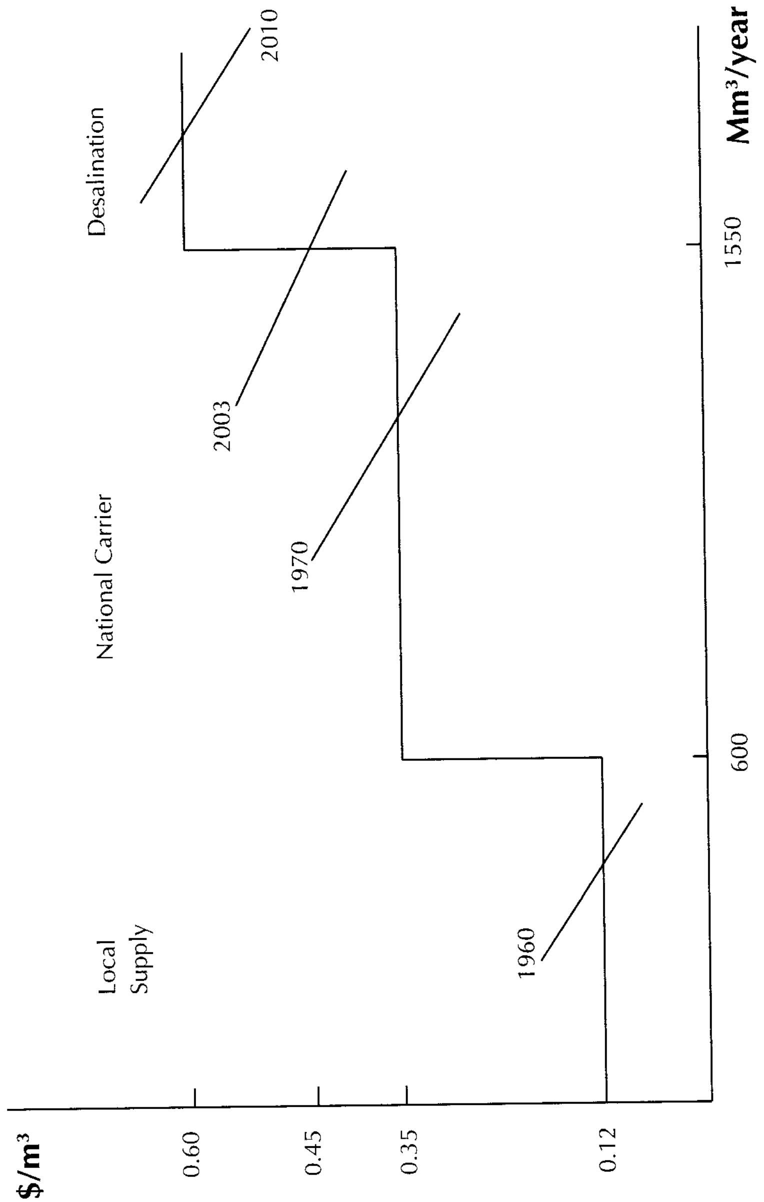

Figure 10.4 Three Epochs in the Water Economy of Israel Water and Irrigated Products (1952 = 100).
Source: State of Israel, Central Bureau of Statistics, *Statistical Abstract of Israel*, various years.

The index of real prices of water (deflated by the consumer price index) is depicted in figure 10.5. The index aggregates prices paid to Mekorot and to other suppliers. Since 1952 the price of water has increased two and a half times. But, as the graph clearly indicates, water prices did not increase markedly in the 1960s when water from the more expensive National Water Carrier was first delivered to the south. Price increases were made politically feasible by the dramatic rise in energy costs, in the early 1970s. This observation helps to explain the different experiences of Israel and the western United States.

It was recently reported[12] that farmers in Central Utah paid 0.7 cents per m^3 while the value of the marginal productivity of water was 2.5 cents per m^3, and the cost of providing the water was 25 cents per m^3. Farmers in California paid 1.2 cents per m^3. The American prices are much lower and the gap between cost and user pay is much wider than the corresponding values common in Israel. The explanation may lie in the nature of the supply. Most of the water supplied by the large projects in the Western United States is captured in dams and moved by gravity. The major component of cost is capital; this is sunk cost (i.e., cost that cannot be recovered) and, with the conventional accounting practices, it does not figure in the current public budgets. In contrast, Mekorot elevates water from Lake Kinneret, 215 meters below sea level, close to 400 meters to the hills and pushes it southwards. Israel's is therefore an energy intensive water project and the agricultural political lobby could not prevent a Treasury burdened by increasing energy bills from making Mekorot's consumers share in the cost. Private and regional suppliers were affected by the increasing energy prices directly, in their electricity bills.

The other graph in figure 10.5 depicts the index of the real prices farmers received for products of irrigated agriculture (crops, horticultural products, and flowers). Since the mid-1950s, except for the decade of the 1970s, the index has shown a downward trend, reflecting developments in world markets where abundant supply has historically reduced food prices.[13] Farmers in Israel were caught in the scissors action of rising water prices and decreasing product prices. The consequences are clearly seen in figure 10.6: up to the mid-1980s water used by farmers exceeded the quota (aggregate quota of the sector) but, since then, agriculture has used less water than the quota allowed. True, some farmers may have been limited by the quota, but for the sector as a whole, in the last two decades, water was allocated by prices – of water and products – and not by the administrative quota.

As indicated earlier, most of the quotas have been stable since the early 1970s. The dips in the mid-1980s and in 1990 are reflections of temporary cuts in allocation to agriculture when shortages occurred; particularly severe was the second crisis. The crisis of 1999–2002 is still not reflected in the figure. For many farmers, quotas did not change, but not for all. There has been a persistent increase in aggregate quota throughout the period

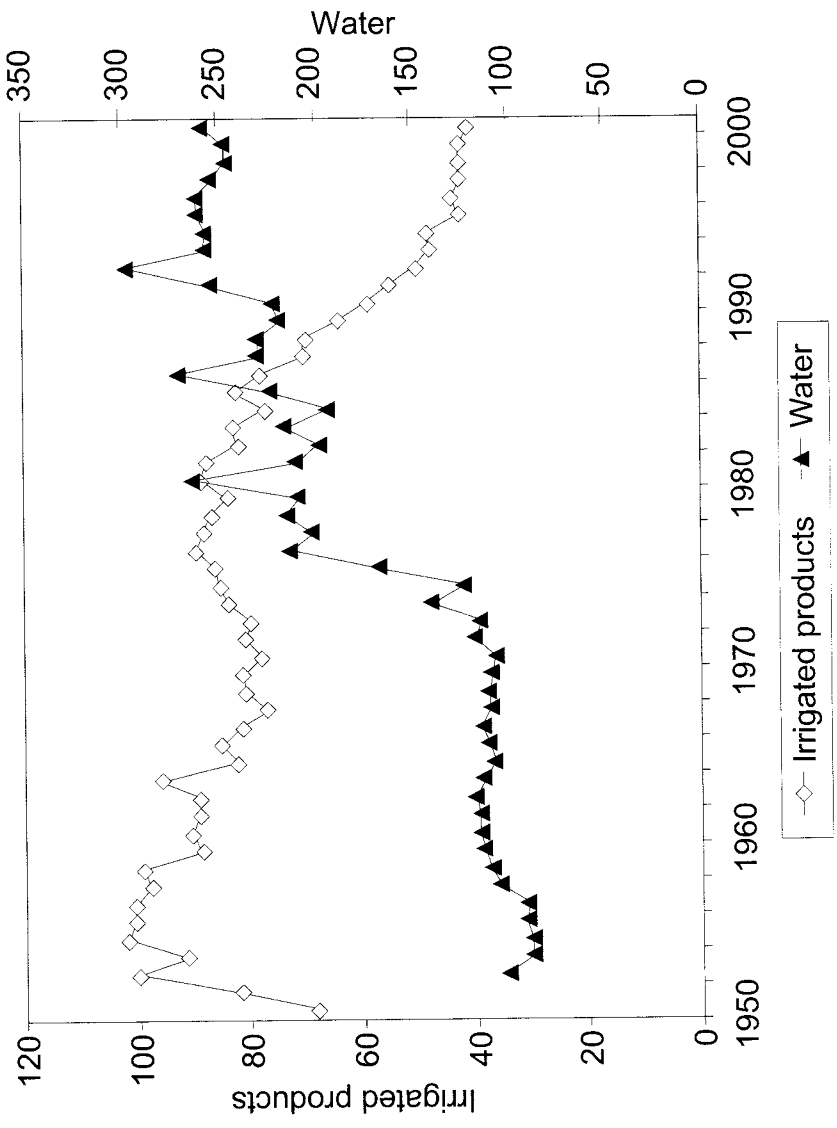

Figure 10.5 Price Indices in Agriculture, Water and Irritated Products (1952).
Source: State of Israel, Central Bureau of Statistics, *Statistical Abstract of Israel*, various years.

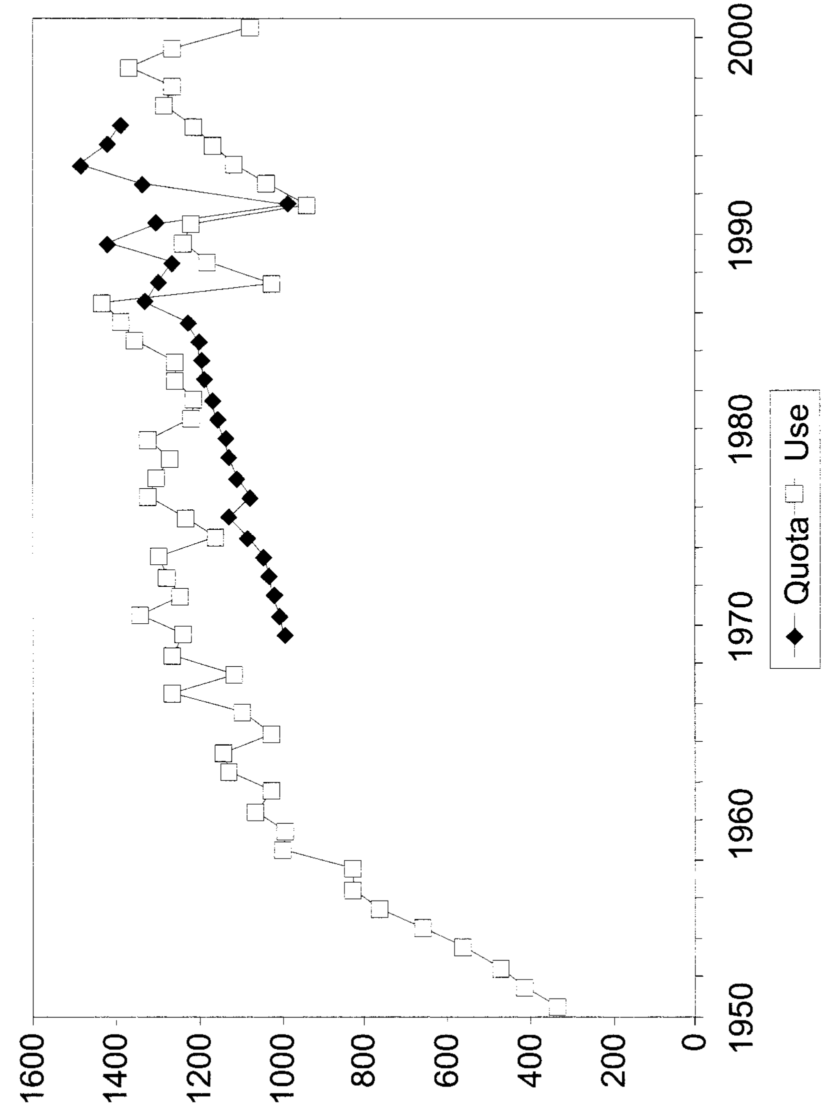

Figure 10.6 Water in Agriculture, quota and use (Mm³ per year).
Source: For uses: State of Israel, Central Bureau of Statistics, *Statistical Abstract of Israel*, various years. For quota: Assaf Perez, *Water Market Regulations in Israel: Quota, Prices, and Political Lobbying* (Rehovot: Hebrew University of Jerusalem, MSc Thesis, 1999).

covered in the diagram. The crisis of 1990–91, like the current one, was created by a period of drought following years of over-drafting and tight supply. Still, allocation to agriculture kept expanding and the expansion policy was myopic: the cost of the crisis may turn out to be higher than the cost of gradual and controlled reduction in supply.

The increased allocation to agriculture encouraged use of water in the sector (we shall soon see how) despite gradual growth in fixed demand for urban water. The resulting over-drafting need not be large (estimates vary); even the smallest annual gaps accumulate, as every household with a bank account knows, whether in theory or from experience. A jackpot may however save, at least for a while, a financially careless family. Israel hit a jackpot in the winter of 1991–92 when rains surpassed all records (figure 10.3), reservoirs were filled to capacity and the books were reopened on blank pages. The policy of over-drafting of the last several years is evidence of a refusal to recognize that the roulette seldom returns a second time to favor lavishly the same player.

Prices and Subsidies

Water prices represented by the index of figure 10.5 were average payments per m^3. Mekorot customers in agriculture pay block rate prices that rise with the amount purchased: 20 cents per m^3 for any quantity up to 50% of the quota (the first block), 25 cents for the next 30% and 32 cents for additional amounts. The purpose of this price structure is to combine support to agriculture with economic efficiency: support comes through lower prices for part of the amount used and efficiency is allegedly assured due to the fact that the marginal unit is paid at full price. Although the introduction of block rate pricing in 1989 had some economic benefits, the claim that it is an efficient pricing system is flawed in more than one way.[14] We shall not go here into technical details, but will consider one effect of the method: by increasing the quota of a farm, as was occasionally done (figure 10.6), the Water Commissioner extended the range of lower blocks. In this way he reduced the average price that the farmer paid and increased the support the farm received. Block rate pricing thus gave the Water Commissioner powers that the legislators of the original Water Law did not have in mind. Moreover, in expanding the quota, the Water Commissioner encouraged use of water by the fortunate farmers who got the new allocations, even if the aggregate quantity was determined by prices.

Economic support must be covered somehow and, indeed, the government covers regularly 15–20% of the cost of Mekorot.[15] But this is not the whole picture; municipalities pay Mekorot "at the city gate" a wholesale price of 35 cents per m^3, while the average price the farmers pay is only 25 cents per m³. In this way, the urban consumer cross-subsidizes water in agriculture. There is, however, another way to look at the price structure and the cross-subsidization it implies. As indicated earlier, all farmers pay the same price and similarly municipalities pay one price. But costs vary; farmers in the far south and in the hills pay less than the cost of supply to their areas, while farmers in the north and center pay more than the cost. Similarly, Tel Aviv, located on the coast, pays more and Jerusalem, at a higher elevation, pays less than its specific cost of water provision. Economic considerations would call for adjustment of prices to cost, but I cannot see the politician who will survive even a mild support of a rise in water rates in Jerusalem, the holy capital, relative to Tel Aviv, the city of business and entertainment.

Economic considerations not withstanding, governments often subsidize business and other activities. Water is a convenient medium of support; it carries the subsidy to the end of the pipeline, where costs are relatively high and farming conditions are harsh. Support of sectors in need is a government prerogative but good public housekeeping demands that costs be calculated properly and subsidies indicated explicitly in the budgets. General "principles" of one price, which implicitly support some users more than others, obscure policies and reduce their effectiveness.

Extraction Levies

Another, new form of price is the *extraction levy*, which was imposed in 2000.[16] Consider figure 10.4: as the demand for the year 2003 is depicted, consumers – farmers and others – are willing to pay more for water than the pecuniary cost of 35 cents per m³. In the diagram, if the price for 2003 is set at 35 cents, the quantity the consumers of all sectors will try to use exceeds the available amount of 1,550 Mm³. The marginal value of water to its users is, in the diagram, 45 cents and this will be the equilibrium price equating supply and demand. The difference between the marginal value of the water and the direct cost of supply is termed scarcity value. The extraction levy is set to reflect the scarcity value. If Mekorot is charged 10 cents as the extraction levy for water delivered through the National Water Carrier, the cost of the company, and the price the consumers will pay, will be the equilibrium price of 45 cents per m³. The scarcity value of local water is even higher and so also will be the extraction levy. This is the idea behind the extraction levy; the tax is calculated to reflect the "scarcity value" of water. It is imposed on well operators, including Mekorot, and it varies by region according to specific regional scarcity values. The current rates are between 10 and 13 cents per m³.

This is not the place to go into a detailed discussion of the pros and cons of the extraction levy, but it is appropriate to emphasize that the levy is an important economic instrument. When the levy is in effect, water users are confronted by the scarcity values. The levy makes users take the social effect of individual pumping into their own private considerations and, with it, they behave less as "free riders" and more as considerate users of a scarce resource. Although pump taxes are used in some places, I do not know of any country outside Israel that has introduced scarcity prices for water.

Needless to say, farmers opposed the extraction levy vehemently. It passed, despite their opposition, with the help of political horse-trading. Initially it was just a change of title; payments to the Equalization Fund were renamed extraction levies, and the farm lobby was "bribed" by a promise that all money accumulated in the defunct fund will go to support recycling projects. Once the levy was established, it could be raised and expanded to regions that were originally not covered by it. Also, evidently, the passage of the levy is an indication of the waning political power of agricultural interests.

The shift from equalization contributions to extraction levies was not just a change of title. In principle, there is an important difference between the two. Equalization charges were assessed on every supplier and well owner individually according to their specific operating costs. The charges encouraged "tax planning" and investments that were not economically justified. Extraction levies should not be affected by the cost of the individual supplier.[17] Payments to the Equalization Fund distorted economic incentives; the extraction levies improve them.

Sewage and Recycled Water

By recent estimates, 60% of the water used in households and industry may be returned as sewage.[18] 80% of the sewage is now collected and treated. Reclaimed water adds 30% to fresh water used in agriculture. This ratio is expected to increase both as the allocation of potable water to farm use is decreased and as sewage collection and diversion of recycled water to agriculture intensify.

As indicated above, the average cost of water to urban areas is 35 cents per m^3. The cost of distributing the water to households and businesses, collecting the sewage, treating it, and getting the recycled water to the farms can add between one and two dollars per m^3. Traditionally, we have regarded the water economy as consisting of the extraction and conveyance systems and viewed the urban water system as its small appendix. But by now, the urban water economy from the city gate to the consumers, to the treatment plant, and to final disposition is not smaller than the economy of fresh water; and it is growing.

The government supports the sewage sector at two levels. At the first, the government finances investment in sewage and recycling projects in municipalities. This line of support from the state to the local authorities grew markedly in the 1990s when the impossibility of enforcing the law requiring municipalities to collect and treat their sewage was recognized. City managers found it so much easier to let the waste flow into the nearest streambed rather than investing in expensive treatment systems.

At the second level, the government supports investment in the adaptation of irrigation to reclaimed water. The cost of adaptation is not negligible; storage is prepared to keep treated water from winter to summer, and new networks are constructed to assure that recycled sewage is not mixed with drinking water. I do not know of assessments of the value of the subsidies entailed by government support to sewage and recycling activities, but essentially most of the initial capital outlays are covered by public funds. Farmers and their regional cooperatives cannot raise on their own the amounts needed for these projects on the capital market.

Judged by its size, the Tel Aviv treatment plant with the pipeline moving its product – high quality reclaimed water – to the Negev in the south is regarded as a national project and operated by Mekorot. For the other places, the accepted doctrine has been to encourage local solutions. In most cases, regional cooperatives take the recycled water from nearby cities. However, local solutions to the sewage problem raise difficult economic questions; for example, should farmers pay the cities for the treated water? Or, how can the cities be assured that the farmers will not reduce usage one day and leave the municipalities with treated water of which they have no way to dispose? The recognition of these problems was one of the motivations for a fresh examination of the national sewage problem in a new master plan,[19] a second motivation will be explained below. The examination will include a comparison of the doctrine of local solutions against the alternative of a central conduit that will carry treated sewage from the coastal region to the Negev.

Quality Issues

Several sources add salts to the water reservoirs in Israel; we shall consider two examples. In the north, salty springs flow into Lake Kinneret; in the coastal area, winds deposit on the ground drops of water carried from the Mediterranean Sea and the rains drain the salt into the aquifer. In the past, under natural conditions, when water was not extracted from the reservoirs, equilibrium prevailed; on average, a certain amount of salt was added yearly and the same amount was withdrawn. The process was visible in Lake Kinneret: nearby springs of brackish water added salt to the lake and the Jordan River drained it towards the Dead Sea. A similar process operated under the ground in the aquifers. Under natural conditions, on average, the same amount of water added yearly by rain to the aquifer (the replenishment) flowed into the Mediterranean Sea. The flow carried with it, again on average, the same amount of salt as was added annually.

Identical, on average, input and output flows kept the salt content of the reservoirs constant. Thus 100 years ago salt concentration in the Coastal Aquifer was some 60 mg of Cl per liter (chloride is an easily-measured and common proxy for salt content) and the water was regarded as having high quality. The natural salt content of Lake Kinneret was approximately 350 mg Cl per liter. As part of the construction of the National Water Carrier, several of the salty springs were diverted to the Jordan River south of the lake (in the Chloride [Saline] Water Carrier; figure 10.1) and, as a result, the salt concentration was reduced to 230 mg Cl per liter,[20] a level considered tolerable for most crops. Today, when water from Lake Kinneret is pumped to the National Water Carrier, salt from springs that were not captured and diverted is also carried in the pipelines. In this way, the concentration of salt in the lake is kept from increasing.

The situation in the Coastal Aquifer is different. In the epoch of local supply (figure 10.4), wells pumped water from the aquifer for irrigation above it. The flow from the aquifer to the ocean was reduced and most of the irrigation water evaporated. Part of the salts carrying water filtered to the subsoil and the groundwater. Four sources have further added salts and other pollutants to the coastal aquifer in the last several decades. One was irrigation over the aquifer with water from Lake Kinneret; the second was heavy use of fertilizers in agriculture that resulted in some chemicals, particularly nitrogen, leaking into the groundwater; the third source was salts seeping into the aquifer when extraction reduced water-level, thus lowering the pressure that had kept salty water at bay; and the fourth source was urbanization with leaking sewage, oil, and industrial pollutants. The average salt content of the Coastal Aquifer has reached 200 mg Cl per liter and is rising. More than a few wells are not operated anymore because of particularly high local concentration of pollutants. The situation is even worse in the Gaza Strip and in the smaller aquifers north of the Coastal Plain.

Pollution and water quality are the second motivation for the fresh examination of the sewage problem mentioned in the previous section. Treated effluents are significantly saltier than the background water (water used in households and businesses from which the sewage was collected) and, even after treatment, the water may be polluted with other undesired chemical and biological ingredients. The use of reclaimed water, depending on the degree of treatment, is therefore limited to insensitive crops. In addition, irrigation with recycled water above aquifers may pollute the underlying reservoirs rendering their water unsuitable for home use and, in the long run, also for agriculture. The Water Law empowers the Water

Commissioner to act in preventing pollution, but strict regulations have not been enacted as of yet. It seems that the regulator and his advisers are seeking compromises between the needs of sustainable aquifers and policies the farmers can live with.

Municipal Water Services

Municipalities get water from their own wells or they purchase it from Mekorot. They are responsible for delivery to households and businesses and for the collection of sewage and its treatment. Prices paid by consumers, including a sewage charge, are set by the government to cover municipal costs. The price is calculated to cover cost of depreciation and maintenance components but local politicians – not unlike their colleagues at higher levels of government – are short-run maximizers; the municipalities neglect maintenance and use the funds saved to finance visible, aboveground projects. The consequences are obsolete networks, water losses, and local authorities whose interest lies, not in saving, but in increasing water use. The government is attempting to privatize municipal water supply; the model often referred to is Buenos Aires, where a French company took over the city's water services.[21] The change is slow; municipalities are reluctant to lose the goose that lays the golden eggs.

Water Markets

By the wording and the spirit of the law, users cannot sell their water rights. In reality there has always been substantial trade in water, some of it officially sanctioned and some without the knowledge of the Water Commissioner. Moreover, in the cooperative villages (moshavim) the quota is allotted to the villages, and farmers may buy from the village pool or sometimes sell to it. Consequently, at present, some farmers have access to traded water while others are barred from it.

The justification of the official anti-trade attitude was the need to maintain flexible policies that can be modified as circumstances change. It was thought that markets would strengthen the hold of private parties on their water, and the property rights so created will stand in the way of proper management of the resources. This consideration was somewhat theoretical; in practice, even now, when trade is officially forbidden, stable quotas are taken as belonging to the farmers and cannot be modified arbitrarily ("possession is nine points of the law"). Across the board cuts are acceptable in emergencies, such as in time of drought. Justly so, prices are the most efficient instrument of allocation in regular times but they are not the right means in emergency situations. It is impossible to determine the exact price that will cut water use by the needed amount for one or two years, and increasing the price of water in time of shortage will ignite strong political opposition – "not only do we have less water but the price also rises!"

Emergency situations are, however, the appropriate time for trade in water. Indeed, water markets in California were most active in dry years.[22] When quotas are cut administratively, some farmers are left with allocations they do not need and others are under-supplied. Trade may amend this deficiency. Unfortunately, the Ministry of Agriculture and the Water Commissioner joined forces and announced recently that water transfers were strictly forbidden in time of crisis. The inability to enforce the restrictive policy can be expected to change the underlying philosophy.

Rules vs. Discretion

The law gives the Water Commissioner (and the minister above him) a set of powerful instruments to enforce the chosen policy. The law does not, however, specify the policy or the duties of the commissioner. The implication of the omission is that the lawmakers trusted the Water Commissioner to manage by discretion, to use professional judgment in formulating policies and directing the sector. Experience taught, however, that management by discretion failed. Throughout the years, the Water Commissioner allowed over-drafting, the sector was brought at least twice to a severe crisis, and aquifers have been depleted and polluted. This need not be so. Management may be by rule whereby mathematical and economic models[23] can be formulated to calculate alternative rules and to assess their effects, such as whether and by how much to curtail supply to agriculture in a dry year, or how much water to allocate in a rainy year. Once the principle of management by rules is accepted, the government will be presented with the set of alternative rules and their implications and it will adopt a policy of choice. The performance of the Water Commissioner will be judged by his adherence to the rules and by the pre-specified goals achieved.

It may seem that the objective of the shift to management by rule is to clip the wings of the Water Commissioner. In some degree it is, particularly in light of past experience. But this effect should not be exaggerated; a Water Commissioner under strong political pressure is not that independent, and his wings are not stretched very wide. Moreover, water management will always be management under uncertainty. With management by rule the Water Commissioner is relieved of part of the responsibility for risky, often painful, policies.

Concluding Remarks

In the opening of the survey I expressed my opinion that the basic structure of the water economy of Israel was sound. The question is: what changes and reforms are now needed, particularly in view of the current crisis and the policies that led to it?

The crucial action to take immediately is to reduce sharply water supply to agriculture (this will naturally entail heavy compensation of affected farmers). There is no other way; the first desalination plant on the Mediterranean Sea, operating since 2004, adds only 100 Mm^3 yearly – less than 5% – to the country's water supply. Other plants will be even slower to come. Unless there is an exceptionally rainy year, following a policy of mild reductions in water allocation to agriculture will cause severe and irreparable damage to Israel's water resources. All experts agree on the damage; some assert, however, that the Coastal Aquifer is already lost as a high quality reservoir and in the future its water will require purification and desalinization. The aquifer, they conclude, can now be mined to keep agricultural water use at the current level until desalination in large quantities replaces it.

The mining possibility illustrates clearly the necessity that the government (I mean the cabinet, the highest level) becomes involved in the water economy more than it has been in the recent past (the governments of the 1950s were very much involved). The mining of the Costal Aquifer will have large financial and political implications and the decision cannot be left to the administrative level. And this is not the only question of major importance that the water sector is now facing. Several other issues are waiting to be resolved with a long run perspective in mind. This is the motivation for my suggestion above of management by rule.

Israel has the expertise and the legal and administrative basis to execute the needed reforms. But the reforms cannot be taken for granted; governments have short attention spans, and they have to be pushed. The public and the media will push if they are informed. A great deal of information on the water economy is constantly accumulating, but most of it is of a technical nature, not accessible to the public at large. The policy and its underlying considerations must be made open and explained to the public.

Reforms hurt vested interests; politically they are accepted only in severe and painful crises. One hopes that the current crisis is painful enough. Once the sector is reformed, the public discussion of water will be more rational than it has been to date. This will also open the way for a rational discussion of regional water issues, matters of war and peace in the Middle East and the subject of our gathering for this conference.

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Notes

1 For an excellent discussion of common resources, see G. Hardin, "The Tragedy of the Commons," *Science* 162 (1968): 1243–48.

2 The information is from The State of Israel, The Water Commission, *The Tasks of the Water Economy of Israel in the Long Run* (Tel Aviv: 2000, in Hebrew). The available supply of 1,550 Mm^3 per year is of water to use in Israel, the Golan Heights (north-east and east of the Lake Kinneret), and the Jewish settlements in the West Bank and Gaza Strip. Earlier, higher estimates (a number often cited was 1,830 Mm^3) included water lost in floods, used in the West Bank, and supplied now to Jordan.

3 The Negev is the southern part of the country. In figure 10.1, roughly the area south of a straight line from Hebron to Gaza.

4 Nablus is not in Israel proper; it is located in the West Bank, in the territory controlled now by the Palestinian Authority (figure 10.1). It can, however, be taken as representative for the northern, rainy parts of Israel.

5 Chapter 9, in this volume.

6 Tony Allan, *The Middle East Water Question* (London: I. B. Tauris, 2000).

7 For a theoretical exposition of political lobbying in the water economy, see Pinhas Zusman, "Informational Imperfections in Water Resource Systems and the Political Economy of Water Supply and Pricing in Israel," in: Douglas D. Parker and Yaacov Tsur (eds.), *Decentralization and Coordination of Water Resource Management* (Boston: Kluwer Academic Press, 1997), pp. 133–54.

8 The assertion can be proved mathematically in a model of political lobbying. See Gene M. Grossman and Elhanan Helpman, "Protection for Sale," *American Economic Review* (1994): 84 (4), 833–50.

9 Overdrafting of aquifers is not unique to Israel. "Virtually everywhere, governments and farmers have their heads in the sand on the groundwater problem – but it is not going away. Irrigation cutbacks will occur." Sandra Postel, *Pillar of Sand: Can the Irrigation Miracle Last?* (New York: W. W. Norton & Company, 1999), p. 251.

10 Some farmers own private wells and others, around and above Lake Kinneret, pump directly from the lake or the Jordan River (all under license).

11 The price implicit in the contract signed recently with the company chosen to build the first desalination plant was surprisingly low, 53 cents per m^3. Connecting to the National Water Carrier will increase the cost somewhat.

12 Erin Schiller and Elizabeth Fowler, *Ending California Water Crisis: A Market Solution to the Politics of Water* (San Francisco: Pacific Research Institute, 1999) (downloaded from <www.pacificresearch.org>).

13 Robert W. Fogel, "Catching up with the Economy," *American Economic Review* (1999): 89 (1): 1–21.

14 Ziv Bar-Shira and Israel Finkelshtain, "The Long-Run Inefficiency of Block-Rate Pricing," *Natural Resource Modeling* (2000): 13(3), 471–92.

15 Cost and subsidy information in this passage is from the budget of Mekorot Water Co., Ltd, various years.

16 Takdin, Israel laws and regulations, "Water Regulations (Extraction Levies) 2000" (Compact Disk, 2001, in Hebrew).

17 The difference is not complete; the levy may be lowered for high cost private (non-Mekorot) suppliers. It is not known yet how important this provision will be.

18 Water Commission, "The Tasks," p. 6. This assessment seems however to be somewhat optimistic.

19 Tahal, Consulting Engineers, Ltd, *A Master Plan for Effluences in the Center and the South of Israel* (Tel Aviv: 2001, in Hebrew).

20 Executive Action Team (EXACT), Middle East Water Data Banks Project, *Overview of Middle East Water Resources* (U.S. Government Printing Office (1999), p. 31. As part of the peace treaty with Jordan, Israel promised to desalinate the water in the Saline Water Carrier and to supply part of it to Jordan, but this has not been done yet.

21 Lorena Acazar, Manuel A. Abdala, and Mary M. Shrily, "The Buenos Aires Water Concession," in: <econ.worldbank.org/docs/1065.pdf> (n.d.).

22 Richard J. McCann and Eric Cutter, "California's Evolving Water Markets, A Case Study from 1977 to 2000" (2002): University of California at Davis, mimeograph.

23 One possibility is dynamic programming in Markov chains as in Or Goldfarb and Yoav Kislev, Management Rules for the Water Economy under Uncertainty, *The Economic Quarterly* (2002): 49 (2) 602–25 (Hebrew).