# Best Practices in Agricultural Water Demand Management and Comparative Analysis for Israel

**Rachel Bergstein**
**New Israel Fund/Shatil Social Justice Fellow for Friends of the Earth Middle East**

**June 2010**

*Image by Kevin Dooley under Creative Commons license*

This study was undertaken as part of the Jordan River Rehabilitation Project, supported by the United States Agency for International Development (USAID), the Goldman Fund, the Global Nature Fund/ Ursula Merz Foundation and the Green Environment Fund.

**EcoPeace/ Friends of the Earth Middle East**
**Amman, Bethlehem and Tel Aviv**
**www.foeme.org**

# Table of Contents

# I. Introduction

In Israel today, agriculture (and, necessarily, agricultural water use) are the legacy of the country's Labor Zionist agricultural ideology. From the pre-state emergence of a Jewish nationalist movement until the right-wing Likud party came to power in Israel in 1977, Labor Zionism was the dominant ideology within the Zionist movement (and later the State of Israel). Labor Zionism envisioned physical agricultural work as a means of reconnecting to the national homeland. A.D. Gordon, one of the most influential Labor Zionist thinkers, viewed agriculture as a means of spiritual rebirth of the Jewish people (Tal, 2007).

Since water is a fundamental prerequisite for agricultural productivity, expanding water availability for agriculture became Israel's primary water management objective. The National Water Carrier, completed between 1950 and 1964, is a system of centralized pipes and canals that integrated fresh waters from the Upper Jordan River and Lake Kinneret in the wet north and made them easily accessible for agriculturalists in rural and peripheral locations in the drier center and south. Initial financial estimates for the projects cost were $15 million during the first eight years. Considering that during this period Israel's total foreign currency earnings did not exceed $20 million, this sum certainly demonstrates the state's commitment to agricultural priorities (Tal, 2007). In addition, heavy water subsidizes were established for the agricultural sector to help extend agricultural expansion. Furthermore, since the development of land for Jewish agriculture was also seen as part of "reclaiming" the land from its Arab inhabitants, agricultural settlements were often strategically placed in peripheral areas to establish a Jewish presence. These areas were far from water resources, so the government undertook the expensive project of connecting them to the national water system (Selby, 2003). All of these activities were carried out with the single objective of supporting agricultural expansion.

The development of agricultural water technology, for which Israel is famous around the globe, was also a direct result of the country's ideological commitment to agriculture. Drip irrigation, for instance, which is now used extensively throughout the world, was invented in Israel as a means of increasing per-unit productivity of scarce water resources.

In the past three decades, Israel has transformed rapidly from an agriculture-based economy to a services-based economy. In 2008, agriculture added 2.6% to Israel's economy (Israel Central Statistics Bureau, 2009). The debt crisis within the Kibbutz movement in the 1980s, as well as the rise of the high-tech industry in the 1990s propelled the agriculture's economic decline (Feitelson, 2002). The dominance of agriculture within the political and social fabric of Israel, however, remains a lasting legacy.

The importance of agriculture, rooted in Israel's Labor-Zionist origins, remains a strong political force. The ideological primacy of agriculture was also manifested at the political level. From the birth of the state in 1948 until 1996, Israel's water policies were entirely under the jurisdiction of the Ministry of Agriculture, and all of the Water Commissioners except two were representatives of the agricultural sector (they were then transferred to the Ministry of National Infrastructures, but continued to yield to pressure form the agricultural lobby). Furthermore, from October 1975 to July 1992, a sub-committee of the Knesset Finance Committee dominated by members of the agricultural lobby set agricultural water prices, and the majority of public representatives in the Water Council [today the Water Authority] represent Israeli farmers (Knesset Parliamentary Committee of Inquiry on the Israeli Water Sector, 2002).

Although only a very small percentage of Israeli citizens actively engage in agricultural production, the agricultural lobby remains highly influential because of the "deeply embedded pro-rural impulse that resides in decision-makers regardless of their political affiliation. Israelis identify with the verdant landscape of the countryside and see something wholesome in its preservation." (Tal, 2007) Because agricultural issues are inextricably bound in Israel's national identity, agricultural reform (particularly in the water sector) often proves to be a fairly intransient political issue.

Until the early 1990s, water management related to agriculture in most countries around the world, including Israel, focused on the expansion of supply through infrastructure, technical solutions, and efficiency ("more crop per drop"). As global water resources have become scarcer due to population growth and resource degradation, **water demand management** (hereafter *WDM)* has emerged as the leading water management paradigm. WDM can be loosely defined as "doing better with what we have," as opposed to increasing supply (Winpenny, 1994, cited in Molle, 2009). It marks a shift toward achieving the sustainable use of water. Water demand management emphasizes meeting diverse demands for water (economic, environmental and social) to match user's needs, greater citizen participation in decision making and institutional structures, and encouraging a greater role for market mechanisms (Pahl-Wostel et al., 2008, cited in Organisation for Economic Co-operation and Development [OECD], 2010). WDM increases water savings, often at a lower cost than supply-driven water policies like desalination and wastewater reclamation that have large financial and environmental costs.

Largely due to its foundational agricultural ethos, Israel is a global leader in agricultural water use and conservation. Israel treats and reuses a higher percentage of wastewater than any country in the world, pioneered the invention and global dissemination of ultra-efficient drip irrigation systems, and even fares better than other developed countries in cost recovery in agricultural water pricing. Still, the agricultural sector consumes the lion's share of water in Israel, using over half (57%) of the country's water resources, including over a third (37%) of freshwater. (Friends of the Earth Middle East [FoEME], 2010). Furthermore, environmental pressures like population growth and climate change are adding – and will continue to add - further stress to Israel's water resources. The widespread adoption of agricultural WDM policies is therefore critical for the sustainability of Israel's water economy.

The following paper will review key strategies for water demand management in the agricultural sector. It will explain to what extent these tools have been adopted in Israel (if they have been adopted at all) and with what degree of success, as well as present examples of successful agricultural WDM policies from around the world.

## II. Pricing Tools

### 1. Overview

Pricing tools treat water as an economic good. These tools include various pricing schemes as well as quotas, and markets.

- ***Volumetric pricing mechanisms*** "charge for irrigation water based on the quantities of water consumed. A special case of volumetric pricing is marginal cost pricing. Marginal cost pricing equates the price of a unit of water with the marginal cost of supplying the last unit of water. ." (Johansson et al, 2002)
- ***Non-volumetric pricing methods*** charge for irrigation water based on a per output basis, per input basis, a per area bases, or based on land values.
- ***Quotas*** are a system of administrative allocation in which users are allotted a certain quantity of water. Quotas are often used when marginal price costs are high and would place an unsustainably heavy financial burden on farmers.
- ***Water markets*** rely on market pressures to determine the price for irrigation water by allowing users to buy and sell quota allotments. Successful water markets are predicated on a strong institutional framework, including well-defined, tradable water rights, appropriate infrastructure and institutions for distributing water.

The costs of water include the supply costs (operation and maintenance, fixed capital costs), economic costs (opportunity costs for alternative resource uses, economic costs of externalities) and social costs (environmental or public health externalities) (OECD, 2010a). Full-cost water pricing is widely endorsed, although most often conceptualized to include only supply costs. The Organization for Economic Cooperation and Development (OECD), for instance, actively promotes the adoption of full supply cost pricing policies among member states (Kevin Parris, personal communication, 31 May 2010). The European Union's Water Framework Directive also recognizes pricing as a central tenet of sustainable water management and calls for all member states to adopt full cost pricing by 2010, but includes both economic and social costs in this objective (OECD, 2010a). It is unclear, however, how successful this strategy is as a lone mechanism for achieving conservation in the agricultural sector. Some research suggests that bulk water pricing is a successful strategy for recovering supply costs and maintaining irrigation infrastructure, but does not provide a sufficient price incentive for farmers to conserve (Molle, 2009). On the other hand, prices that reflect the actual scarcity of water are politically and financially unfeasible; a study by the European Commission found that to halve agricultural water abstractions, water prices would have to increase anywhere from 200-1500%. In Fuenta Palmera in Spain's Gudalquivier basin, for instance, simulation of water savings response showed that a 50% increase in prices led to potential water saving of 28% of current water use because farmers would abandon low value maize conservation and concentrate irrigation for higher value crops. To achieve a 50% savings in irrigation, however, prices would need to be increased 550%. According to same simulations, in the Upper Rother river basin in the UK, a price increase of 1542.9% would be necessary to reduce irrigation abstractions by 50% because most agricultural users are already producing high-value crops, and real water prices are very low (Dworak, Strosser, & Joyce, 2009).

Since pricing alone may not be completely effective in achieving WDM goals, it may be most effective when it is used in combination with other measures. For example, price incentives are often used at the margin to control use in excess of defined quotas or entitlements (Molle, 2009). Quotas are a particularly desired strategy for dealing with scarcity conditions because they can be revised downwards in response to water availability.

Water markets, which are predicated on quota or entitlements allotments, are the least developed of these tools. Water markets establish water as a good that can be traded between users. Water permits or allocations are distributed among users, who are free to buy and sell from each other. This system allows water to be transferred to its highest valued usage. Water markets are seen as a desirable tool because they are more flexible and efficient, letting market pressures set prices instead of a centralized authority. Water markets are also seen as creating a double incentive for the development and implementation of conservation technology because new water users must pay a market price for their water, and existing water users can sell their water savings for more than its opportunity costs. Markets also increase the number of possible outcomes for resolution of water-based conflicts between users (Garry, 2007).

## 2. Application in Israel

Water in Israel is priced using a combination of volumetric pricing and quotas. The Head of the Water Authority (formerly the Water Commission) determines water quotas. Base "historic" quotas are allocated according to each farm or agricultural settlement's location, land area, total land suitable for irrigation, cropping patterns, and soil types (MARD, 2009; World Bank, 2006 cited in OECD, 2010b). Ideally these quotas are to be adjusted annually to reflect prevailing water realities, but in reality these quotas have remained largely untouched since the 1970s (Kislev, 2001). In 1993, a more flexible mechanism was introduced, whereby the Water Authority allocates 75% of the quota at the beginning of the winter (around October), and then allocates the remaining portion in March/April depending on the amount of rainfall during the winter months (OECD, 2010b). After a severe drought in 1999, quotas were reduced 44%, based on crop type. In 2008, Israel decided to reduce its freshwater allocation to agriculture from 530 MCM to 350 MCM by 2015 (OECD, 2010b).

Israel's agricultural water quotas are non-binding, and are enforced through water pricing at the margin. As of 2010, most farmers pay $0.419/CM for up to 50% of quota, $0.494/CM for 50-80% of quota, and $0.645/CM for 80-100% of quota. Farmers who exceed their quota pay $0.968 per unit up to an excess of 8% (Israel Water Authority, 2010). Cost varies somewhat across region in consideration of pumping and transportation costs (Netanyahu, 2010). In the Beit Shean Valley, for instance, costs are as low as $0.127/CM. Costs for recycled wastewater are much lower; water from the Shafdan Sewage Treatment Project, for instance, is $0.276/CM. [1]

These prices reflect significant subsidies. Agricultural water is cross-subsidized by the domestic sector, which pays much higher rates for water. Additionally, Israel has traditionally provided direct government support to Mekorot to cover part of operation

[1] These prices based on an exchange rate of 3.8 NIS=1 USD.

and maintenance (O&M) and fixed capital costs (OECD, 2010b). Current agricultural water prices reflect these market distortions. Although the previously stated fees reflect a 25% increase as of January 1, 2010, when the Head of the Israeli Water Authority increased all water prices in Israel to respond to drought conditions, these rates are still far below market price. The marginal cost of water in Israel, when estimated to include the external environmental and social costs (air pollution and emission of greenhouse gases during desalination and pumping, water pollution from brine discharge, use of valuable coastal land, etc), reaches $0.88-$0.92/CM (FoEME, 2010). Additionally, since reduction of water quotas began in 1999 Israeli farmers have been compensated by payments. In 2002 and 2003 these payments peaked at 160 million NIS ($35 million USD) (OECD, 2010b).

In periods of drought, Israel has introduced pricing measures to encourage conservation. During a serious drought between July 1990 and May 1992, water prices increased 47% for the third block (80-100% of quota). However, many farmers were able to adjust to the pricing schedule by reducing use relative to quota, meaning they remained in lower pricing brackets. Therefore the marginal cost increased less than the pricing schedule reflects (Netanyahu, 2010).

Changes in recent years indicate that farmers respond to price increases in Israel. An increase of 12.4% in water prices in 2005, for instance, reduced demand by 2.3% relative to the previous year. Cost of water as a total input in agriculture was 7.9% in 2003, rising to 8.9% in 2005, impacting the cost of agricultural production and therefore creating an incentive for farmers to conserve water (Statistical Abstract of Israel 2006, cited in Netanyahu, 2010). Israel intends for agricultural water prices to reflect the average cost of water production (O&M and fixed costs) by 2015. This goal implies a gradual elimination of cross-subsidization and support for Mekorot, as well as an increase in agricultural water prices and complementary investments in water efficiency to help agricultural water users bear the increased costs (OECD, 2010b).

Since the 1980's the majority of Israeli agricultural users have used water at levels below their quota (Netanyahu, 2010). This indicates that quotas in Israel do not properly reflect economic or environmental considerations relating to Israel's water economy. Furthermore, it indicates that pricing, rather than quotas, have a greater impact on water usage in Israel's agricultural sector.

In 2007, Israel also introduced an Extraction Levy for well operators, including both Mekorot and privately owned wells. This charge was introduced as a demand management measure to encourage users to draw from recycled wastewater and local sources, thereby protecting increasingly scarce water resources. The size of the levy varies regionally depending on scarcity values (Netanyahu, 2010). Although a demand management measure, the Extraction Levy also reflects agricultural water subsidies, since farmers are charged lower levies than industrial and household consumers (OECD, 2010b).

Israel's Water Law of 1959 establishes water as a public good under the jurisdiction of the state. Water markets therefore, are technically illegal in Israel because water consumers do not "own" the water they are allocated, so are therefore not able to buy and sell it freely. In reality, however, many agricultural consumers participate in informal water trading. In moshavim (cooperative agricultural villages), farmers often buy from or sell to the village pool (Kislev, 2001). Illegal sales of unused agricultural quotas are estimated at more than 20 MCM per year (Lictman, 2007 cited in OECD, 2010b). In 2008 the government agreed to allow holders of water allocations to sell up to 30% of their allocation by transferring the transaction to other agricultural users via the National Water Carrier (Axelrad and Feinerman, 2009, cited in OECD, 2010).

## 3. International Best Practices

The European Union's Water Framework Directive was adopted in 2000. It establishes a legal framework to protect and restore water resources across all EU member states. One of its central Common Implementation Strategies requires all EU states to adopt full cost water pricing (including environmental costs) by 2010 (Garrido & Calatrava, 2010).

An analysis by the Organisation for Economic Co-operation and Development (OECD) of the Ebro River Basin suggests that in accordance with WFD implementation, a 0.12 €/CM increase in water prices would reduce agricultural water demand by 509 MCM. This increase would likely result in €287 million of revenue due to the decline in acreage of cereal and woody crops. An increase of €0.18/CM would reduce demand by 605 MCM due to an *abandonment* of cereal and woody crops, leading to a loss of €405 million. In both cases, compensation to farmers is recommended in exchange for their voluntarily accepting water price increases (Albiac, Martinez, & Tapia, 2005).

Global experience shows that the effectiveness of water pricing as a WDM tool varies depending on the *demand elasticity* of water in the region. *Demand elasticity* measures how much demand changes in response to prices. It varies based on factors including the proportion of water within farmers' total production costs, availability of alternative crops, technologies, or water resources, and technical, social, or economic constraints. According to a 2005 World Bank Study, "In such cases, water prices have to increase substantially before they will significantly reduce water demand. In the process, farmers' income will be adversely affected.

In parts of Spain, some estimates suggest that farmers' incomes would need to fall by 25 to 40 percent before an increase in the price of water would lead to significantly lower water consumption (Berbel and Gomez-Limon 2000). In a case in Iran, water prices would have to be raised from $4/1,000 CM to $20/1,000 CM to significantly reduce demand (Perry 2001)" (Tiwari and Dinar, 2005). In France's Charente river basin prices successfully reduced irrigation demand because of a high demand elasticity for water. However, the increase in prices significantly reduced farmers' revenues, so local authorities abandoned pricing and shifted to a quota system. (Montginoul & Rieu, 2001, cited in Rieu, 2010).

Another example of pricing practices is seasonal or peak pricing. A higher price is charged during the dry season when water is scarce and a lower price is charged in the wet season when water is more readily available. If the high is sufficiently high in the dry season, it will limit the area irrigated during that season. In France, for instance, pricing structure is based on different costs for "peak" use (five months in the summer) and "non-peak" water use. During peak season charges reflect the long-run marginal cost of supplying water, while in the off-peak prices only include operation costs. This pricing structure has helped reduce water use during the summer when demand is high

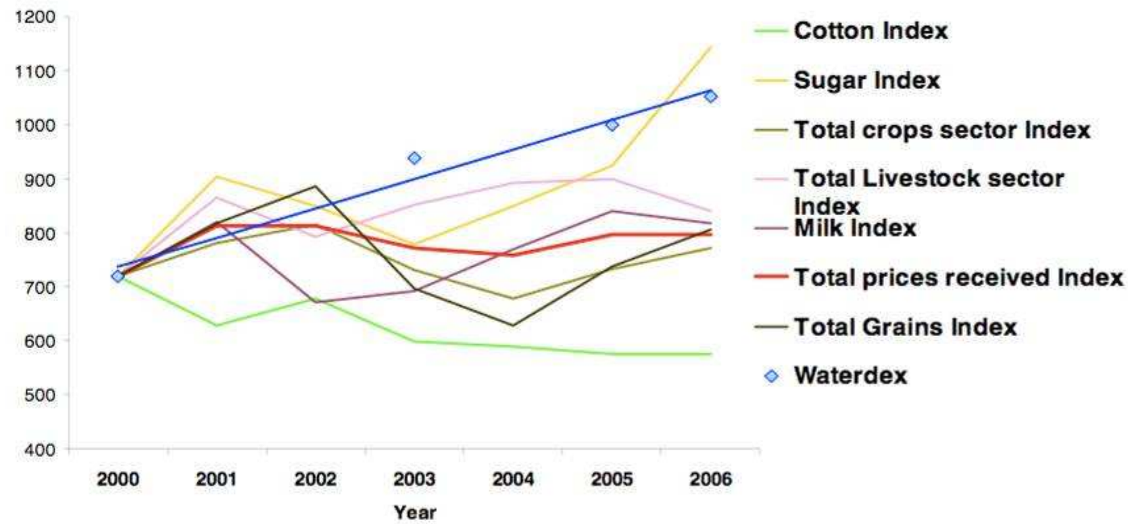
(Tiwari and Dinar, 2003; Johansson et al, 2002).

In some cases, pricing tools are used at the national planning level. In New Zealand, the National Water Act sets the provision for fixing irrigation abstraction quotas. In the Riet River and its tributary the Modder River downstream of the Krugersdrift dam, this law limits abstractions to 35% of the full quota delivered from the Krugersdrift Dam.

Some countries have successfully adopted models similar to Israel's, which combine quota and pricing tools. In the Genil Cabral cooperative in Spain's Gudalquivier Basin the computerized control system allows the cooperative to impose penalties on farmers whose consumption exceeds the limit by over 10%. The excess, up to 10%, is billed at twice the unit price, and any volume over this limit is billed at 25 times the unit price (Molle, 2009). In The Communidad de Regantes de Mula in Spain's Segura basin farmers each have a personal "ATM" card for ordering irrigation water. Each farmer is given a quota. If this quota is exceeded, farmers pay an additional 50% per unit, while if users save water below their quotas they receive a 25% tariff reduction. (Dworak et al, 2007).

Water markets are an emerging phenomenon, but there are already some successful examples worldwide. In Australia's Murray-Darling Basin agricultural users are granted Water Access Entitlements, which entitle them to a *share* of water, rather than a proportionate amount or a volumetric allocation. Figure 1 illustrates the increasing market price of water entitlements over time with little/no correlation to value of agricultural commodities; water entitlements have clearly become more valuable over time (Young, 2010).

**Figure 1:** ***Relationship between long-run national water entitlement price index and the indices of the value of agricultural commodities developed by the Australian Bureau of Agricultural Economics***




***Source: Young, 2010***

The Colorado-Big Thompson River market in the United States is another widely-cited example. The C-BT project is a major trans-mountain water storage and transportation system in the Northern Colorado Water Conservancy District (NCWCD). One allotment unit is defined as 1/310,000$^{th}$ of the quantity of water annually declared to be available by the Board of Directors of the NCWD (the C-BT project was constructed for the storage and delivery of 310,000 acre-feet). Willing buyers and sellers are able to sell their allotments on an open market. Although originally created to address short-term variability, available statistics show that the institution of a water market has led to permanent transfers of water, mostly from agricultural to municipal and industrial uses (Kempner and Marido, 1999).

In Spain, both the Tajo to Segura basin and the Guadalquivir-Almeria basin are water markets that have also seen a transfer from extensive irrigation to high-value horticulture. Data for 2007 showed a market price of around €0.24/CM (including interbasin transfer costs). This price is below the estimated per-unit cost for desalinated water, €0.40/cubic meter (CM), indicating the economic efficiency of demand management strategies (in this case the establishment of a water market) over desalination. (Dworak et al, 2007)

In 1992 the California Department of Water Resources began operating a Drought Water Bank, as well as a dry year water purchase program on behalf of State Water Project contractors. Responding to increasingly acute drought conditions, in 2009 the DWR once again began operating a water bank to coordinate water transfers between willing sellers and buyers (California Department of Water Resources Local Planning and Assistance, 2009). The Drought Water Bank purchases water from willing sellers from water suppliers upstream of the Sacramento-San Joaquin Delta, and then transfers this water using State Water Project or Central Valley Project facilities to water suppliers facing water shortages due to drought conditions. Water acquired by the Drought Water Bank became available for purchase by public and private users based on needs criteria (California Department of Water Resources, 2008).

## III. Removing Trade Barriers

### 1. Overview

In the agricultural sector, trade barriers are often imposed as a way for a country to encourage local production by protecting local markets from international competition. However, evidence shows that trade in *virtual water* can reduce agricultural water demand on a national scale. *Virtual water* refers to the volume of water consumed in the production of a product, measured over its full production chain. Nations that import or export that product are therefore importing or exporting water in its virtual form.

The theory of comparative advantage posits that "nations can gain from trade if they concentrate or specialize in the production of goods and services for which they have a comparative advantage, while importing goods and services for which they have a comparative disadvantage" (Wichelns, 2001, 2004 cited in Chapgain, Hoekstra & Saveniji, 2006). Therefore, a virtual water trade flow from a country with high water productivity or rich water resources to a country with low water productivity or scarce water resources results in a net water savings (Chapgain, Hoekstra & Saveniji, 2006). Trade barriers, however, can restrict the virtual water trade, so the removal of these barriers may increase water savings.

### 2. Application in Israel

A 2009 report by the OECD found that Israel provides a high level of support for its farmers. In 2008, state support for farmers equaled 25% of total gross agricultural product. This support takes the form of input subsidies (including water subsidies, see section II), as well as protectionist policies for agricultural produce like high import taxes and quotas (Cohen, 2009). The dairy industry, for instance, is almost completely protected from foreign exports, except for a few minor imports required by the World Trade Organization and bilateral trade agreements. Some protections exist in the fruit and vegetable sector, depending on the crop, local price, and growing season. Phyto-sanitary regulations on banana production, for instance, serve as a non-tarriff barrier protecting domestic banana production from international competition (FoEME, 2010). FoEME's analysis indicates that opening these markets to international trade could reduce freshwater use in dairy production by 30 MCM annually (nearly two thirds of the freshwater use in this sector) and in banana production by 15 MCM annually (three fourths of the freshwater use in this sector) (FoEME, 2010).

Although exact estimates vary, most analysis consistently demonstrates that Israel is highly dependent on international trade in virtual water. Kislev calculates, for instance, that Israel meets less than 50% of its food, household, and industrial needs with domestic water resources (2001). Buckwald suggests that Israel is dependent on virtual water imports for 81% of its daily caloric intake (2000, cited in FoEME, 2007). In the period of 1997-2001, Israel's net water savings from international trade were 9.8 billion cubic meters (Water Footprint Network, 2008). Ironically, despite its reliance on virtual water imports, Israel continues to export virtual water in the form of high value crops like flowers, fruits, and vegetables. Israel exports between 89 and 24 MCM each year of virtual freshwater. When marginal waters are included, this figure rises to 257 MCM annually (FoEME, 2007).

### 3. International Best Practices

Experience from other nations shows significant national water savings from international virtual water trade. Japan, the nation with the largest net water saving from international agricultural trade, saves 94 billion cubic meters of water annually through the import of cereal crops, oil-bearing crops, livestock, and stimulants (coffee, tea, and chocolate). These are products that would otherwise be produced domestically in Japan, consuming Japan's own water resources.

The following table lists the nations with the largest net water savings as a result of international trade of agricultural products (Chapgain, Hoekstra & Saveniji, 2006).

**Figure 2: Nations with the largest water saving as a result of international trade of agricultural products. Period 1997-2001.**

| Countries | Net national water saving ($Gm^3/yr$) | Major partners ($Gm^3/yr$) | Major product categories ($Gm^3/yr$) |
|---|---|---|---|
| Japan | 94 | USA (48.9), Australia (9.6), Canada (5.4), Brazil (3.8), China (2.6) | Cereal crops (38.7), oil-bearing crops (23.2), livestock (16.1), stimulants (9.2) |
| Mexico | 65 | USA (54.0), Canada (5.1) | Livestock (31.0), oil-bearing crops (20.5), cereal crops (19.3) |
| Italy | 59 | France (14.6), Germany (6.0), Brazil (5.4), Netherlands (4.4), Argentina (3.1), Spain (3.1) | Livestock (23.2), cereal crops (15.2), oil-bearing crops (12.9), stimulant (8.1) |
| China | 56 | USA (17.4), Brazil (8.3), Argentina (8.3), Canada (3.6), Italy (3.4), Australia (3.2), Thailand (2.6) | Livestock (27.5), oil-bearing crops (32.6) |
| Algeria | 45 | Canada (10.8), USA (7.6), France (7.1), Germany (4.0), Argentina (1.6) | Cereal crops ( 33.7), oil-bearing crops (4.0), livestock (3.4) |
| Russian Fed. | 41 | Kazakhstan (5.2), Germany (4.4), USA (4.1), Ukraine (3.4), Brazil (3.3), Cuba (2.4), France (1.9), Netherlands (1.9) | Livestock (15.2), cereal crops (7.1), sugar (6.9), oil-bearing crops (4.3), stimulant (3.8), fruits (2.3) |
| Iran | 37 | Brazil (8.3), Argentina (8.1), Canada (7.7), Australia (6.0), Thailand (2.2), France (2.0) | Cereal crops (22.5), oil-bearing crops (15.1), sugar (1.6) |
| Germany | 34 | Brazil (8.3), Cote d'Ivoire (5.3), Netherlands (5.0), USA (4.2), Indonesia (3.3), Argentina (2.2), Colombia (2.1) | Stimulants (21.8), oil-bearing crops (15.0), fruits (3.4), nuts (2.3) |
| Korea Rep. | 34 | USA (15.6), Australia (3.6), Brazil (2.2), China (1.5), India (1.4), Malaysia (1.2), Argentina (1.1) | Oil-bearing crops (14.3), cereal crops (12.8), livestock (2.3), sugar (1.9), stimulants (1.5) |
| UK | 33 | Netherlands (5.3), France (3.7), Brazil (2.8), Ghana (1.9), USA (1.8), Cote d'Ivoire (1.5), Argentina (1.4) | Oil-bearing crops (10.1), stimulants (9.5), livestock (5.2) |
| Morocco | 27 | USA (7.8), France (6.4), Argentina (3.3), Canada (2.2), Brazil (1.2), Turkey (0.8), UK (0.8) | Cereal crops (20.9), oil-bearing crops (4.4) |

***Source: Chapgain,*** **Chapgain, Hoekstra & Saveniji, 2006**

## IV. On-Farm Efficiency

### 1. Overview

Some policies create an incentive for agricultural water users to adopt water demand management measures themselves. Other policies may take the form of direct assistance to farmers in adopting water conserving measures. On-farm efficiency programs include subsidies, educational programs and training, and investment in water efficiency technologies.

## 2. Application in Israel

The Ministry of Agriculture provides support for agricultural water efficiency through research, planning, education for farmers, and financial support for improving farming methods. Israel provides on-farm invstment grants for farmers to install drip irrigation and other water saving technologies, as well as supports research and development on new water saving technologies and systems (OECD, 2010b). The Agricultural Extension Service, a subsidiary body of the Ministry of Agriculture, has offices all over Israel, and provides technical support and training for farmers on a variety of issues, including efficient irrigation methods (Ministry of Agriculture [MoAg], n.d.). Since Israel is a world leader in agricultural water efficiency technologies, many private companies also offer training and technological services to farmers as part of their marketing strategy. Netafim, for instance, a pioneer in the field of drip irrigation and agricultural technology, maintains three training centers throughout Israel (Netafim, 2010).

Israel currently plans to significantly reduce its freshwater allocation to agriculture by 2015. Under this plan, farmers who can provide evidence that they have made investments in improving on-farm water effiency and savings will receive financial compensation (OECD, 2010b).

## 3. International Best Practices

A “pilot study” of the Cidacos River in North-Central Spain ranked measures for saving water and therefore increasing river flow. When ordered by unit cost (€/CM saved), the most economically efficient measures prove to be investments in extension services for farmers’ skill building, starting with farmers who irrigate with more than 5,000 CM/1000 dunams and changes in irrigation system and distribution network (Dworak et al, 2007).

The United States Department of Agriculture’s Natural Resource Conservation Service (NCRS) runs the Agricultural Water Enhancement Program (AWEP), which provides financial and technical assistance to agricultural producers who voluntarily implement on-farm water conservation activities United States Department of Agriculture [USDA], 2010a). NCRS also provides Conservation Innovation Grants (CIG). The CIG program is a “voluntary program intended to stimulate the development and adoption of innovative conservation approaches and technologies while leveraging federal investment in environmental enhancement and protection, in conjunction with agricultural production”(USDA, 2010b).

The government of New South Wales, Australia introduced the WaterWise on the Farm program between 1998 and 2005 to improve on-farm water use efficiency. The program engaged over 5,000 irrigators (out of a total of 12,000 throughout the state) in training, farm planning, and investment in water efficient technologies. Water use efficiency savings were estimated at up to 25%, with an increase in crop yields of 20% (Dworak et al, 2007).

An EU-LIFE project in Optimizagua, Spain between October 2003 and September

2006 also addressed water saving potentials by experimenting with combinations of artificial intelligence and traditional water control systems. This project "combined an innovative technology based on programmable automatic machines; data communication and transmission devices using General Packet Radio Service (GPRS); sensors for detecting the moisture in the soil and the time of year; the incorporation of renewable energies in the prototype itself, and the integration of the set of traditional systems for the collection and storage of rainwater (tanks, lakes or ponds) for their subsequent reuse for irrigation purposes." (EU LIFE, cited in Global Nature Fund [GNF], 2009). This project was found to reduce irrigation by up to 60%.

## VI. Environmental Policies

### 1. Overview

Reducing agricultural water demand is environmentally beneficial, but the decision to manage demand may not necessarily be informed by environmental goals. However, if a state commits to certain environmental quality or quantity goals, these aims are often achieved through polices that mange agricultural water demand.

### 2. Application in Israel

Since the establishment of the state in 1948, Israel's rivers, streams, and aquifers have steadily declined in quantity and quality. Y. Bar-Or explains,

> Since the establishment of the State of Israel in 1948, the country has absorbed, at a rapid pace, massive waves of immigration from European and Middle Eastern countries, and has undergone accelerated urbanization and industrialization. As a result, and due to low environmental awareness, the coastal rivers progressively became receivers of insufficiently treated wastewaters and solid wastes of diverse origins. In order to supply the needs of the growing population, larger and larger amounts of groundwater were pumped from aquifers, and there was less and less freshwater discharging to the rivers from springs at their sources. Aquatic and wetland habitats subsequently dried up, and some segments of the coastal rivers, such as the Ayalon and Dalia rivers, were converted to concrete channels designed exclusively to protect cities against floods (2000).

In 1994 the Ministry of the Environment (now Ministry of Environmental Protection) established the River Restoration Administration as a coordinating body to help restore Israel's deteriorated streams and rivers. Rehabilitation and restoration has been difficult, however, because of inadequate water flows; almost all of Israel's renewable freshwater is diverted for agricultural, urban, and industrial consumption (Bar-Or, 2000).

In recent years, the concept of a "right of nature to water" has emerged in Israel. In 2003, an Israeli government decision allocated 50 million cubic meters (MCM) of water to water for nature. In 2004, Israel's Water Law was amended to include an additional purpose for water to the five already enumerated: "the conservation and rehabilitation of natural assets and landscapes including rivers, springs, and wetlands." (Israel Ministry of Environmental Protection [MoEP], 2006). The Ministry of Environmental Protection and the Nature and Parks Authority conducted a study that led to allocation recommendations for the restoration of Israel's water bodies. At this time, however, there are no concrete policies or programs that outline how allocation of water to nature will be achieved. Between 2007 and 2010 only 7-9 MCM was actually allocated to nature (Gidon Bromberg, personal communication, 24 June 2010). Furthermore, the allocation of water for nature in Israel is intended to rehabilitate national streams only, so it excludes the Lower Jordan River because it is an *international* river, even though it is one of Israel's largest and most degraded river systems.

## 3. International Best Practices

Irrigated land retirement is one example of an environment-related policy that returns water to nature. Irrigated land retirement programs provide financial incentives for farmers to remove cropland from agricultural production. When their land is removed from production, water that would otherwise be used for irrigation can be diverted elsewhere. Often irrigated lands are retired to achieve environmental aims like a reduction in water salinization or the restoration of wetland areas.

The Conservation Reserve Enhancement Program (CREP) is a joint federal-state conservation program run by the United States Department of Agriculture (USDA). Eligible participants voluntarily enroll in 10-15 year contracts. The Republican River CREP in Colorado has enrolled 141,640 dunams in the Republican River Basin. The retirement of this cropland is estimated to reduce irrigation water consumption in this basin by 5 percent. The Upper Arkansas River in Kansas is another CREP program intended to manage water demand. When the UAR program was initiated in 2006, it aimed to enroll 80,937 dunams, which would lead to an estimated reduction of 36.7 MCM of water annually (United States Department of Agriculture [USDA], 2007). California's Central Valley Project Improvement Act (CVPIA) of 1992 is another example of irrigated land retirement. This law authorized government purchase of agricultural land and associated water rights from receivers of Central Valley Project water. This program is expected to retire about 404,685 dunams of irrigated farmland. The savings potential for this program is 609-915 CM/dunam, assuming all users receive their entire water allocation. (California Department of Water Resources, 2009)

The Living Murray is a river restoration initiative of the Murray Darling River Basin Authority. One of the most well-known river restoration projects in the world today, it was launched in 2004 as a response to the declining health of the Murray river system. This initiative aims to restore the ecology of the river basin. Among other measures like increased environmental monitoring and the construction of environmental infrastructure, one of the main programs of the Living Murray is the Water Purchase Project, in which the Basin Authority set out to purchase 500 MCM from willing sellers at appropriate market prices. The Water Purchase Project is funded by investments from the national government of Australia, as well as the state governments of New South Wales, Victoria, South Australia, an the Australia Capital Territory. As of December 2009, 485 MCM had been recovered, 97% of the total goal. (Murray Darling Basin Authority, 2010)

## Conclusion

Israel is known worldwide as a leader in agricultural water efficiency. Still, like many other countries around the world, Israel has not fully adopted water demand management as the governing paradigm for addressing water scarcity. Although the state has made some inroads in transitioning to water demand management in the agricultural sector, such as through raising prices, the prevailing policy still largely focuses on augmenting supply. Furthermore, allocations of freshwater to nature – streams, wetlands and springs – remain low. As environmental awareness has increased in Israel so too has public pressure for the rehabilitation of rivers and streams, but with relatively few successful results.

In the coming decades, as population grows and climatic changes reduce water availability in the region, it will become more important than ever for Israel to adopt the structure of a sustainable water economy. FoEME recognizes that policies are implemented within a particular social, economic, and political context, and that the policies cited in this paper may not necessarily be successful or as successful if implemented in Israel. These examples do, however, demonstrate that water demand management policies have been successful when adopted in other parts of the world. FoEME therefore calls for Israel to study the feasibility of implementing following changes for reducing water demand in the agricultural sector:

- Adjusting water prices and quotas so that they more accurately reflect the real economic, social, and environmental costs of water supply and provide a price incentive for agricultural users to conserve.
- Permitting water transfers between users and between sectors so water can be directed to its highest value use within society, and provide appropriate institutions to manage these transfers.
- Lowering trade barriers on products like dairy and bananas that prevent the trade in virtual water from reducing domestic water demand. This strategy could reduce water demand in Israel by 45 MCM annually (FoEME, 2010).
- Implementing programs and subsidies to assist farmers in implementing on-farm efficiency programs and technological solutions.
- Adopting irrigation retirement programs to divert irrigation water, specifically fresh water, back to nature or to use it for more highly valued purposes.

Through the implementation of these and other WDM strategies in the agricultural sector, as well as parallel WDM strategies in the domestic sector[2], Israel will be able to achieve meaningful water savings that can be allocated where they are more socially and environmentally beneficial – to higher value economic sectors, to meeting our international agreements with our neighbors, and to rehabilitating our national and regional water resources, most notably the Lower Jordan River.

[2] See *Best Practices in Domestic Water Demand Management*. Http://www.foeme.org

## Works Cited List


Albiac, J., Martinez, Y., Tapia, J. (2005). *Water quantity and quality issues in Mediterranean agriculture*. Prepared for OECD Workshop on "Agriculture and Water: Sustainability, Markets and Policies," Adelaide, Australia.

Bar-On, Y. (2000). Restroation of the Rivers in Israel's Coastal Plain. *Water, Air and Soil Pollution, 123*, 311-321

California Department of Water Resources. (2008). *2009 Drought Water Bank Overview*. California: Author. Retrieved from http://www.water.ca.gov/drought/bank/

California Department of Water Resources Local Planning and Assistance. (2009). *California Water Plan Update 2009: Integrated Water Resource Management*. California: Author. Retrieved from: http://www.waterplan.water.ca.gov/cwpu2009/index.cfm.

Chapgain, A.K., Hoekstra, A.Y., & Saveniji, H.H.G. (2006). Water saving through international trade of agricultural products. *Hydrological Earth Systems Science, 10*, 455-468

Cohen, A. (2009, 18 Aug). OECD to Israel: Privatize farmland, cut water subsidies. *Ha'aretz.* Retrieved from http://www.haaretz.com

Dworak, T., Strosser, P., & Joyce, J. (2009). *Scenarios of Water Demand Management – Impact at Regional Level (Summary).* Berlin: Ecologic, Institute for International and European Environmental Policy. Retrieved from http://ec.europa.eu/environment/water/quantity/pdf/Summary_Scenarios.pdf

Dworak, T., Berglund, M., Laaser,C., Strosser, P., Roussard, J., Grandmougin, B.,…Montesinos, P. (2007). *Final Report – EU Water Savings Potential (Part 1 - Report)*. Berlin: Ecologic, Institute for International and European Environmental Policy. Retrieved from http://ec.europa.eu/environment/water/quantity/pdf/water_saving_1.pdf

Feitelson, E. (2002). Implications of shifts in the Israeli water discourse for Israeli-Palestinian water negotiations. *Political Geography 21*, 293-318

Friends of the Earth Middle East (FoEME). (2010). *Towards A Living Jordan River : An Economic Analysis of Policy Options for Water Conservation in Jordan, Israel and Palestine.* Tel Aviv, Bethlehem, Amman: Author.

Friends of the Earth Middle East (FoEME). (2007). *Nature, Agriculture and the Price of Water in Israel.* Tel Aviv: Author

Garrido, A. & Calatrava, J. (2010). *Agricultural Water Pricing: EU and Mexico*. OECD. Retrieved from http://www.oecd.org/dataoecd/25/38/45015101.pdf

Garry, T. (2007). Water markets and water rights in the United States: Lessons from Australia. *Macquarie Journal of International and Comparative Environmental Law, 4(2),* 23-60

Global Nature Fund. (2009). *Concept Paper 2009: GNF Proposals: Jordan River Rehabilitation Project Sector Agriculture and Domestic Use.* Global Nature Fund. [Unpublished]

Israel Central Statistics Bureau. (2009). Statistical Abstract of Israel 2008. Retrieved from http://www.cbs.gov.il/reader/shnatonenew_site.htm

Israel Ministry of Agriculture. (n.d.). *Making Agricultural Water Use Efficient [Hebrew].* Retrieved from http://www.moag.gov.il/agri/subject/green_agri/yeul_hashimush_bemaim/default.htm

Israel Ministry of Environmental Protection. (2006). *Right of Nature to Water*. Retrieved from http://www.sviva.gov.il > Environmental Topics > Rivers > Right of Nature to Water

Israel Water Authority. (2010). *Water Tariffs 1.1.10*. Israel: Author. Retrieved from http://www.water.gov.il/NR/rdonlyres/20F7141C-EF2F-4F41-A952-45EF3196649A/0/TarifaiMaim250310.pdf

Jagerskog, A. (2003). The power of the "sanctioned discourse" – a crucial factor in determining water policy. Water Science and Technology, 47, 161-166

Johansson, R.C., Tsur, Y., Roe, T.L., Doukkali, R., & Dinar. A. (2002). Pricing irrigation water: a review of theory and practice. *Water Policy, 4*, 173-1999

Kemper, K.E. & Simpson, L.D. (1999). The Water Market in the Northern Colorado Water Conservancy District – Institutional Implications. In Marino, M. & Kemper, K.E. (Ed.s) *Institional Frameworks in Successful Water Markets: Brazil, Spain, and Colorado, USA* (*World Bank Technical Paper 427).* Washington DC: World Bank.

Kislev, Y. (2001). *The Water Economy of Israel.* Prepared for conference on "Water in the Jordan Valley: Technical Solutions & Regional Cooperation," University of Oklahoma, Norman, Oklahoma
Molle, F. (2009). Water scarcity, prices and quotas: a review of evidence on irrigation volumetric pricing. *Irrigation Drainage Systems, 23*, 43-58
Murray Darling Basin Authority (2010). *The Living Murray*. Retrieved from http://www.mdba.gov.au/programs/tlm
Netafim. (2010). *Netafim Instruction Centers [Hebrew].* Retrieved from http://www.netafim.co.il/389/2012
Netanyahu, S. (2010). *The Influence of Regulation and Economic Policy in the Water Sector on The Level of Technology Innovation in the Sector and Its Contribution to the Environment: The Case of Israel*. Retrieved from the OECD website: http://www.olis.oecd.org/olis/2008doc.nsf/linkto/com-env-epoc-ctpa-cfa-rd%282008%2936-final
Organization for Economic Co-operation and Development (OECD). (2010). *Sustainable Management of Water Resources in Agriculture*. Paris: Author.
Organisation for Economic Co-operation and Development (OECDb). *OECD Review of Agricultural Policies: Israel 2010*. Paris: Author.
Parliamentary Committee of Inquiry on the Israeli Water Sector. (2002). Final Report of the Parliamentary Inquiry Committee on the Issue of Water. Jerusalem: Israeli Knesset
Rieu, T. (2005). *Water pricing for agriculture between cost recovery and conservation: Where do we stand in France?* Prepared for OECD Workshop on "Agriculture and Water: Sustainability, Markets and Policies," Adelaide, Australia.
Selby, J. (2003). *Water, Power and Politics in the Middle East: The Other Israeli-Palestinian Conflict.* London: I.B. Tauris
Tal, A. (2007). To Make a Desert Bloom – The Israeli Agriculture Adventure and the Quest for Sustainability. *Agricultural History, 81 (2)* 228-258
Tiwari D,N. & Dinar A. (2001) Role and use of economic incentives in irrigated agriculture (Working Paper). Washington DC: World Bank
United States Department of Agriculture Farm Service Agency. (2006). *Fact Sheet: Conservation Reserve Enhancement Program: Colorado Republican River*. Washington, DC: Author. Retrieved from http://www.apfo.usda.gov/FSA/webapp?area=home&subject=copr&topic=cep-su#P108_3773
United States Department of Agriculture Farm Service Agency. (2007). *Fact Sheet: Kansas Upper Arkansas River: Conservation Reserve Enhancement Program*. Washington, DC: Author. Retrieved from http://www.apfo.usda.gov/FSA/webapp?area=home&subject=copr&topic=cep-su#P108_3773
United States Department of Agriculture Natural Resources Conservation Service. (2010a). *Agricultural Water Enhancement Program (AWEP)*. Retrieved from http://www.nrcs.usda.gov/programs/awep/
United States Department of Agriculture Natural Resources Conservation Service. (2010b). *Conservation Innovation Grants*. Retrived from http://www.nrcs.usda.gov/technical/cig/index.html
Water Footprint Network. (2008). *National water savings and losses due to trade in agricultural products (1997-2001)* [Data file]. Retrieved from http://www.waterfootprint.org/downloads/NationalWaterSavingsDueToTrade1997-2001.xls
Young, M. (2010). *Environmental Effectiveness and Economic Effiency of Water Use in Agriculture: The Experience of and Lessons from the Australian Water Reform Programme.* Retrieved from OECD website: http://dx.doi.org/10.1787/786732081512