

Israel



GEOGRAPHY, CLIMATE AND POPULATION

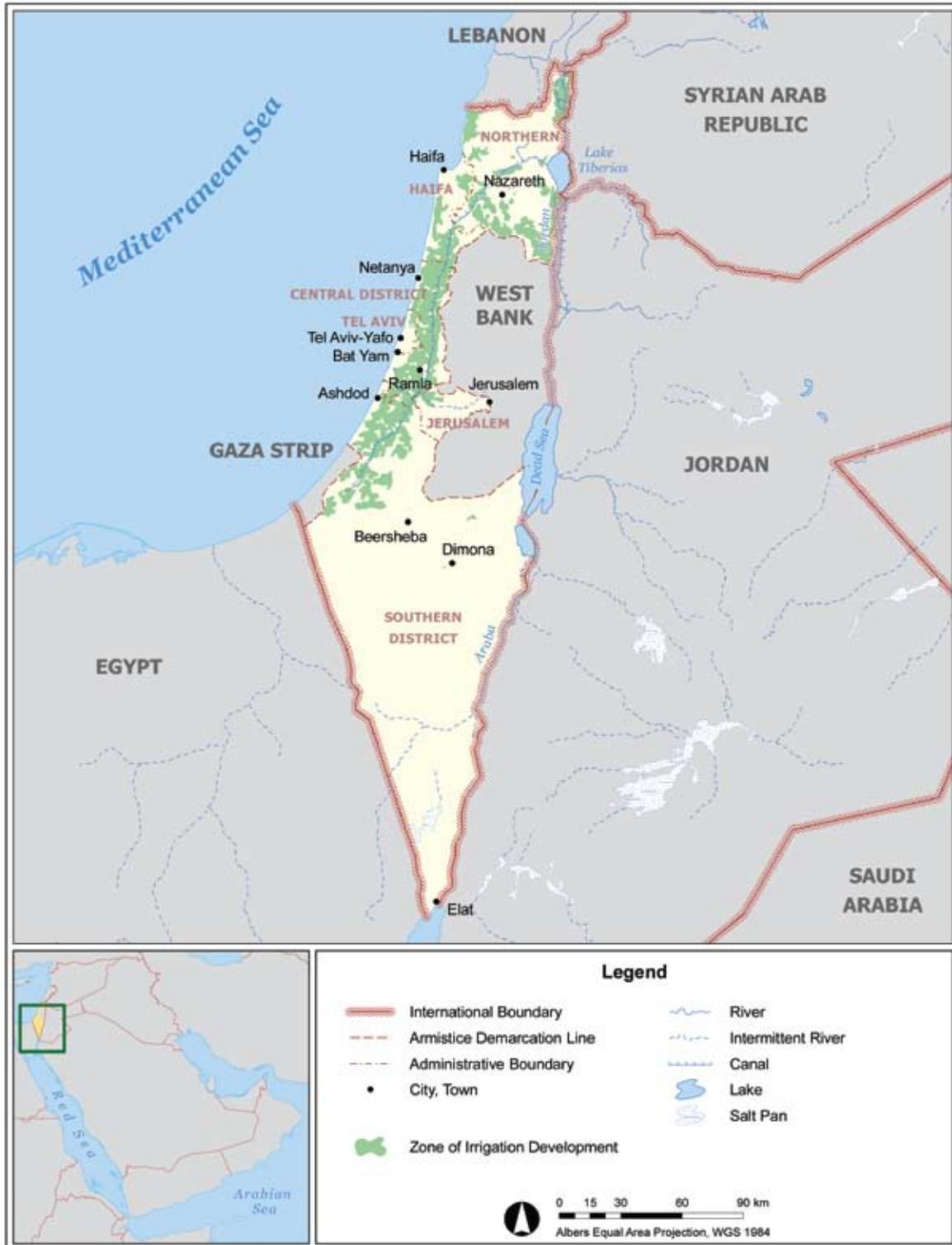
Geography

Israel occupies a total area of about 20 770 km² (CIA, 2008). It is bordered by Lebanon in the north, the Syrian Arab Republic, the West Bank and Jordan in the east, and Egypt and the Gaza Strip in the south and southwest. The total border length is 857 km. It has coastlines on the Mediterranean in the west (194 km) and the Gulf of Eilat (also known as the Gulf of Aqaba) in the south (12 km). Administratively Israel is divided into 6 districts: Jerusalem, Haifa, Tel Aviv and the Northern, Central and Southern districts.

The country is divided into four regions:

- The Mediterranean coastal plain stretches from the Lebanese border in the north to Gaza Strip in the south, interrupted only by Cape Carmel at Haifa Bay. It is about 40 km wide at Gaza Strip and narrows toward the north to about 5 km at the Lebanese border.
- The central highland region. In the north of this region lie the mountains and hills of Upper Galilee and Lower Galilee; farther to the south are the Samarian Hills with numerous small, fertile valleys; and south of Jerusalem are the mainly barren hills of Judea. The central highlands average 610 metres in height and reach their highest elevation at Mount Meron, at 1 208 metres, in Galilee near Zefat (Safad). Several valleys cut across the highlands roughly from east to west; the largest is the Yizreel or Jezreel Valley (also known as the Plain of Esdraelon).
- The Jordan Rift Valley is a small part of the 6 500 km long Syrian - East African Rift. In Israel the Rift Valley is dominated by the River Jordan, Lake Tiberias (also known as the Sea of Galilee and to Israelis as Lake Tiberias), and the Dead Sea.
- The Negev Desert comprises approximately 12 000 square kilometres, more than half of Israel's total land area. Geographically it is an extension of the Sinai Desert, forming a rough triangle with its base in the north near Beersheba, the Dead Sea, and the southern Judean Hills, and its apex in the southern tip of the country at Eilat. Topographically, it parallels the other regions of the country, with lowlands in the west, hills in the central portion, and the Nahal Ha'Arava as its eastern border.

In 2004, the agricultural area in Israel amounted to 428 000 ha. Of the total agricultural area 43 percent was in the Southern and Jerusalem Districts, 42 percent in the Northern and Haifa Districts and 13 percent in the Central and Tel Aviv Districts. Moreover 75 percent of the agricultural area was used by collective localities, 10 percent by other Jewish farms and 15 percent by non-Jewish farms (CBS, 2004). In 2005, the cultivated area covered 392 000 ha, of which 317 000 ha of annual crops and 75 000 ha of permanent crops (Table 1).



ISRAEL

FAO - AQUASTAT, 2008

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TABLE 1
Basic statistics and population

| Physical areas | | | |
|--|------|-----------|-----------------------------|
| Area of the country | 2008 | 2 077 000 | ha |
| Cultivated area (arable land and area under permanent crops) | 2005 | 392 000 | ha |
| • as % of the total area of the country | 2005 | 18.9 | % |
| • arable land (annual crops + temp. fallow + temp. meadows) | 2005 | 317 000 | ha |
| • area under permanent crops | 2005 | 75 000 | ha |
| Population | | | |
| Total population | 2005 | 6 725 000 | inhabitants |
| • of which rural | 2005 | 8.3 | % |
| Population density | 2005 | 323.8 | inhabitants/km ² |
| Economically active population | 2005 | 2 947 000 | inhabitants |
| • as % of total population | 2005 | 43.8 | % |
| • female | 2005 | 43 | % |
| • male | 2005 | 57 | % |
| Population economically active in agriculture | 2005 | 64 000 | inhabitants |
| • as % of total economically active population | 2005 | 2.2 | % |
| • female | 2005 | 20 | % |
| • male | 2005 | 80 | % |
| Economy and development | | | |
| Gross Domestic Product (GDP) (current US\$) | 2007 | 161 820 | million US\$/yr |
| • value added in agriculture (% of GDP) | 2005 | 1.8 | % |
| • GDP per capita | 2005 | 19 292 | US\$/yr |
| Human Development Index (highest = 1) | 2005 | 0.932 | |
| Access to improved drinking water sources | | | |
| Total population | 2006 | 100 | % |
| Urban population | 2006 | 100 | % |
| Rural population | 2006 | 100 | % |

Climate

Israel has a Mediterranean climate characterized by long, hot, dry summers and short, cool, rainy winters, modified locally by altitude and latitude. The climate is determined by Israel's location between the subtropical aridity characteristic of Egypt and the subtropical humidity of the Levant or eastern Mediterranean. January is the coldest month, with temperatures from 5 to 10°C, and August is the hottest month at 18 to 38°C. About 70 percent of the average rainfall in the country falls between November and March, while the months June through August are often rainless. Rainfall is unevenly distributed, decreasing sharply as one moves southward. In the extreme south, rainfall averages less than 100 millimetres annually; in the north, average annual rainfall is more than 1 100 millimetres. Rainfall varies from season to season and from year to year, particularly in the Negev Desert. Precipitation is often concentrated in violent storms, causing erosion and flooding. During January and February, it may take the form of snow at the higher elevations of the central highlands, including Jerusalem (U.S. Library of Congress, 1988).

Population

The population of Israel is 6.7 million (2005), of which 8 percent is rural. The average annual population growth rate was 2 percent during the period 2000–2005. Population density is 324 inhabitants/km² but it is greatly dissimilar from one region to another (Table 1 and Table 2). In 2006, the whole population had access to safe drinking water and improved sanitation.

ECONOMY, AGRICULTURE AND FOOD SECURITY

In 2007 the Gross Domestic Product (GDP) was US\$161.8 billion and, in 2005, agriculture accounted for less than 2 percent of GDP (Table 1). The economically active

TABLE 2
Area and population share by district in 2004 (Central Bureau of Statistics, 2005)

| District | Area (%) | Population (%) |
|--------------|--------------|----------------|
| Jerusalem | 3.0 | 12.1 |
| Northern | 20.7 | 17.0 |
| Haifa | 4.0 | 12.4 |
| Central | 6.0 | 23.5 |
| Tel Aviv | 0.8 | 17.1 |
| Southern | 65.5 | 14.3 |
| Total | 100.0 | 96.4 |

*In 2004, 3.6 percent of total population lived in Jewish localities in the Judea, Samaria and Gaza area

population is about 2.95 million (2005) of which 57 percent is male and 43 percent female. In agriculture, 64 000 inhabitants are economically active, of which 80 percent are male and 20 percent female.

Agricultural export (fresh and processed) for 2005 reached US\$1 680 million, 4.6 percent of the country's total exports. Exported fresh produce amounted to US\$1 024 million, mainly to the European Union, while exported processed food products totalled US\$656 million. In addition, a total of US\$1 900 million of agricultural inputs were exported (2004). This is the outcome of advanced agricultural technology, which has created a thriving industry with sophisticated industrial inputs. Hands-on experience in local agriculture serves as a laboratory for the development, design and manufacture of new input technologies.

Much of Israel's agriculture is based on cooperative communities (kibbutz and moshav), founded on nationally-owned land that is provided on a long-term lease. Some of these communities date back to the early 20th century. The kibbutz is a rural community of several hundred inhabitants who run a large communal production unit. Kibbutz members jointly own the means of production and share social, cultural, and economic activities. Currently, most of the kibbutz income comes from non-agricultural activities (industrial enterprises, agro-tourism and services) and many are undergoing extensive reorganization. Another type of cooperative community, based on 50 to 120 individual family farms, is the moshav, which is defined and registered as an "agricultural cooperative society". The moshav is based on the shared allocation of resources, such as farm land, water quotas, and other productive inputs, as well as, in some cases, the provision of packing and marketing facilities. The residents in both types of communities are provided with a package of municipal services. The kibbutz and moshav communities currently account for more than 80 percent of the country's agricultural produce. A third type of farming community is the non-cooperative moshav, a village of farmers on mostly privately-owned land. Some moshav farmers are organized in local cooperatives operating productive assets (such as packinghouses and wineries). In addition to the Jewish agricultural sector, Arab villages are located in Israel's rural areas. These villages focus mainly on the production of small livestock (sheep and goats), vegetables, field crops and olives (MARD, 2006).

WATER RESOURCES AND USE

Water resources

The only river in Israel is the Jordan. The main sources of fresh water in Israel include:

- Lake Kinneret or Lake Tiberias (the Sea of Galilee), which divides the upper and lower portions of the Jordan River system, is the only natural freshwater lake in Israel. It has traditionally provided about a third of the country's domestic, agricultural and industrial water requirements. Lake Tiberias' catchment area is 2 730 km² and the surface area of the lake is 165 km² with an estimated storage

volume of 710 million m³. Lake Tiberias is the lowest freshwater lake in the world. The total average annual inflow of water into Lake Tiberias amounts to 1 km³, of which some 250 million m³ serve consumers in the region, about 450 million m³ are withdrawn from the lake to serve consumers throughout the country by means of the National Water Carrier and about 300 million m³ are lost by evaporation. The water level has been traditionally regulated between 209 m and 213 m below sea level.

- The Coastal Aquifer is a sandstone aquifer which extends along 120 kilometres of the Mediterranean coastline. It is naturally recharged by precipitation and artificially recharged by water from the National Water Carrier, effluents and excess irrigation water percolating from agricultural, industrial and domestic land uses as well as from streams and wadis. The aquifer is also a valuable storage basin since sandstone layers hold water efficiently. It has a mean annual recharge of 250 million m³ in addition to 50 million m³ of agricultural drainage water.
- The Mountain Aquifer (Yarkon-Taninim) is a limestone aquifer which underlies the foothills in the centre of the country. The basin is comprised of three subaquifers: the Western Basin, known as the Yarkon Taninim Aquifer, flows north and westward and discharges in the Taninim Springs on the Mediterranean coast while the Northeastern and Eastern Basins discharge in the Beit Shean Springs and the Jordan Rift Valley and Dead Sea. The Yarkon Taninim Aquifer is regenerated by precipitation with average annual renewable recharges of about 350 million m³.
- Relatively smaller aquifers are located in Western Galilee, Eastern Galilee, the Jordan Rift, and the Arava valley.

Total internal renewable water resources are estimated at 750 million m³/year (Table 3). About 250 million m³ is surface water and 500 million m³ groundwater and the overlap between surface water and groundwater is considered to be negligible. Surface water entering the country is estimated at 305 million m³/year, of which 160

TABLE 3
Water: sources and use

| Renewable freshwater resources | | | |
|--|------|-------|------------------------------------|
| Precipitation (long-term average) | - | 435 | mm/yr |
| | - | 9.0 | 10 ⁹ m ³ /yr |
| Internal renewable water resources (long-term average) | - | 0.75 | 10 ⁹ m ³ /yr |
| Total actual renewable water resources | - | 1.78 | 10 ⁹ m ³ /yr |
| Dependency ratio | - | 57.87 | % |
| Total actual renewable water resources per inhabitant | 2005 | 265 | m ³ /yr |
| Total dam capacity | | - | 10 ⁶ m ³ |
| Water withdrawal | | | |
| Total water withdrawal | 2004 | 1 954 | 10 ⁶ m ³ /yr |
| - irrigation + livestock | 2004 | 1 129 | 10 ⁶ m ³ /yr |
| - municipalities | 2004 | 712 | 10 ⁶ m ³ /yr |
| - industry | 2004 | 113 | 10 ⁶ m ³ /yr |
| • per inhabitant | 2004 | 296 | m ³ /yr |
| Surface water and groundwater withdrawal | 2004 | 1 552 | 10 ⁶ m ³ /yr |
| • as % of total actual renewable water resources | 2004 | 87.2 | % |
| Non-conventional sources of water | | | |
| Produced wastewater | 2005 | 450 | 10 ⁶ m ³ /yr |
| Treated wastewater | 2005 | 283 | 10 ⁶ m ³ /yr |
| Reused treated wastewater | 2002 | 262 | 10 ⁶ m ³ /yr |
| Desalinated water produced | 2007 | 140 | 10 ⁶ m ³ /yr |
| Reused agricultural drainage water | | - | 10 ⁶ m ³ /yr |

million m³ from Lebanon (including 138 million m³ from Hasbani), 125 million m³ from the Syrian Arab Republic, and 20 million m³ from the West Bank. Groundwater entering the country is estimated at 725 million m³/year, of which 325 million m³ from the West Bank, 250 million m³ from the Syrian Arab Republic (Dan Springs) and 150 million m³ from Lebanon (Lake Hulah). The total renewable water resources are thus 1 780 million m³/year, of which 92 percent is considered to be exploitable. About 25 million m³/year of groundwater flow from the country to the Gaza Strip.

Mekorot, Israel's national water supply company, has built and operated small- and medium-size desalination facilities in the southern part of the country since the 1960s. Eilat at the southern tip of the country by the Red Sea was the first city to use desalination. Some 29 small plants generate 25 million cubic meters of water per year, mainly from brackish water. A decision to desalinate on a larger scale was taken in 2000 as a result of Israel's growing water scarcity. The national goal is to produce 750 million m³/year of desalinated water in 2020 (MAE, 2005). In the near future a string of desalination plants along the Mediterranean coast will produce 400 million cubic meters per year. One large plant for the desalination of seawater was recently completed on the Mediterranean coast, and is now producing 115 million cubic meters a year of potable water (MITL, 2008). Using the reverse osmosis process, this plant is generating water for about 60 cents per cubic meter. All tenders issued for desalination facilities stipulate stringent threshold levels for water quality and provide incentives for even higher water qualities, especially in terms of chloride levels, in order to allow for irrigation without the attendant problem of soil salinity. In 2002, the total installed gross desalination capacity (design capacity) in Israel was 439 878 m³/day or 160.6 million m³/year (Wangnick Consulting, 2002).

Out of a total of 450 million m³ of sewage produced in Israel, about 96 percent is collected in central sewage systems and 64 percent of the effluents are reclaimed (290 million m³); 283 million m³ are adequately treated. Local authorities are responsible for the treatment of municipal sewage. In recent years new or upgraded intensive treatment plants have been set up in municipalities throughout the country. The ultimate objective is to treat 100 percent of Israel's wastewater to a level enabling unrestricted irrigation in accordance with soil sensitivity and without risk to soil and water sources (MOE, 2005).

Water use

In 2004, water consumption amounted to 1.95 km³, almost identical to 2000 and 11 percent more than in 1986 (1.76 km³). Agriculture accounted for 58 percent whereas

it was 64 and 71 percent in 1993 and in 1983, respectively. Municipal use accounted for 36 percent and industrial purposes for 6 percent (Table 3, Table 4 and Figure 1). Freshwater withdrawal amounted to almost 80 percent of the total actual renewable water resources (Figure 2).

Successive years of drought have dramatically lowered water levels in all of the main reservoirs. In fact, 1998/99 was the worst drought year in Israel for the past 100 years. The following years were also characterized by less than average rainfall which led to a shortfall of some 0.5 million m³ in Israel's water balance each year, in

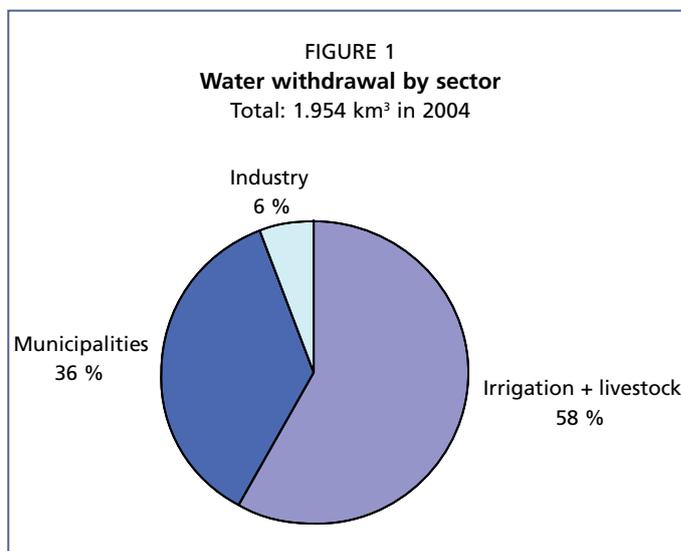


TABLE 4
Water consumption in Israel in million m³ (Statistical Abstract of Israel, 2006)

| | 1990 | | 2000 | | 2002 | | 2003 | | 2004 | |
|-------------------|--------------|------------|--------------|------------|--------------|------------|--------------|------------|--------------|------------|
| | Vol. | % |
| Agriculture | 1 216 | 67 | 1 138 | 59 | 1 021 | 56 | 1 045 | 56 | 1 129 | 58 |
| Domestic purposes | 482 | 27 | 662 | 34 | 688 | 38 | 698 | 38 | 712 | 36 |
| Industrial uses | 106 | 6 | 124 | 6 | 122 | 7 | 117 | 6 | 113 | 6 |
| Total | 1 804 | 100 | 1 924 | 100 | 1 831 | 100 | 1 860 | 100 | 1 954 | 100 |

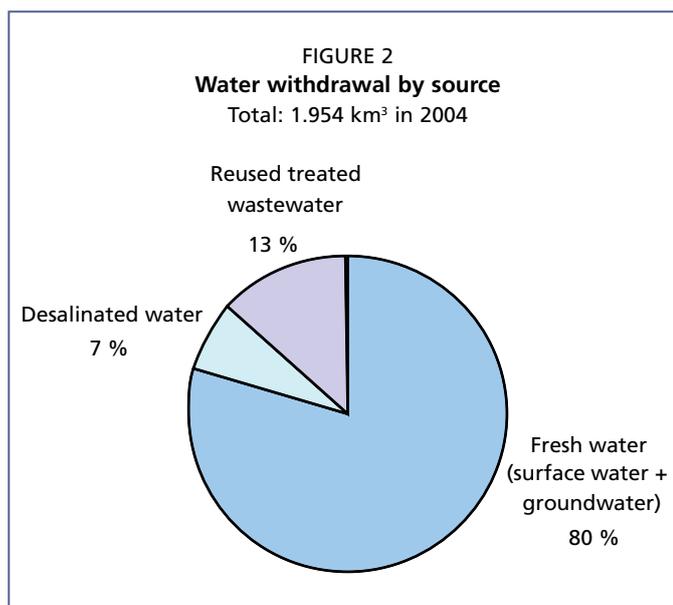
comparison to an average year. The winters of 2002/03 and 2003/04 were characterized by average and higher than average rainfall which led to a significant rise in the water level of Lake Tiberias and in the collection of floodwater in catchment reservoirs. However, the country's aquifers have remained depleted. It is estimated that increased water demand and decreased water availability has led to a cumulative deficit of nearly 2 000 million m³.

The National Water Carrier of Israel (in Hebrew commonly called HaMovil) is the main water project of Israel. Its main task is to transfer water from the rainy north of the country to the centre and arid south and to enable

efficient use of water and regulation of water supply in the country. Most of the water works in Israel are combined with the National Water Carrier, the length of which is about 130 kilometers. Early plans were made before the establishment of the state of Israel but detailed planning started only after Israel's independence in 1948. The construction of the project started during the planning phase, long before the detailed final plan was completed and signed in 1956. The carrier consists of a system of aqueducts, tunnels, reservoirs and large-scale pumping stations. Building the carrier was a considerable technical challenge as it traverses a wide variety of terrains and elevations

International water issues

In 1951, Jordan announced its plan to divert part of the Yarmouk River via the East Ghor Canal to irrigate the East Ghor area of the Jordan Valley. In response, Israel began construction of its National Water Carrier (NWC) in 1953, resulting in military skirmishes between Israel and the Syrian Arab Republic. In 1955, the Johnston Plan called for the allocation of 55 percent of available water in the Jordan River basin to Jordan, 36 percent to Israel, and 9 percent each to the Syrian Arab Republic and Lebanon, and was never signed by the countries involved, since the Arab riparians insisted that the United States government was not an impartial Third Party, but it has served as a general guideline for appropriations within the basin. In 1964, the NWC opened and began diverting water from the Jordan River valley. This diversion led to the Arab Summit of 1964 where a plan was devised to begin diverting the headwaters of the Jordan River to the Syrian Arab Republic and Jordan. From 1965 to 1967 Israel attacked these construction projects in the Syrian Arab Republic, and along with other factors this conflict escalated into the Six Day War in 1967 when Israel completely



destroyed the Syrian diversion project and took control of the Golan Heights, the West Bank, and the Gaza Strip. This gave Israel control of the Jordan River's headwaters and significant groundwater resources. The most recent directly water-related conflict occurred in 1969 when Israel attacked Jordan's East Ghor Canal due to suspicions that Jordan was diverting excess amounts of water (Green Cross Italy, 2006). Later on, Israel and Jordan acquiesced to the apportionment contained in the non-ratified 1955 Johnston Plan for sharing the Jordan Basin's waters (Milich and Varady, 1998). In 1978, Israel invaded Lebanon, giving Israel temporary control of the Wazzani springs that feed the Jordan River. The Golan Heights have been under Israeli law, jurisdiction, and administration since 1981, which however has not been recognized by the United Nations Security Council.

In 1994, the Jordanian-Israeli Peace Treaty included agreed upon articles on water presented in Annex II – water related matters. According to the articles of this annex, Jordan is entitled to store 20 million m³ of the Upper Jordan winter flow on the Israeli side (in Lake Tiberias) and get it back during the summer months. Jordan is entitled to get 10 million m³ of desalinated water from the saline Israeli springs near Tiberias and until the desalination plant is erected Jordan can get this quantity in summer from Lake Tiberias. Jordan can build a regulating/storage dam on the Yarmouk downstream of the diversion point of Yarmouk water to the KAC. Jordan can also build a dam of 20 million m³ capacity on the Jordan River and on its reach south of Lake Tiberias on the border between Jordan and Israel. Later, Jordan and Israel agreed to provide Jordan with 50 million m³ of desalinated water from the Israeli saline springs south of Lake Tiberias, and until the desalination plant is erected, Israel is providing Jordan with 25 million m³ from Lake Tiberias through the summer months. The regulating dam on the Yarmouk River was built and the water conveyor to transport water from Lake Tiberias in Israel to the KAC in Jordan was constructed just after the signing of the Peace Treaty.

More than 40 years of Israeli occupation of the West Bank and the Gaza Strip (WBGS) have been accompanied by a series of laws and practices targeting land and water resources in WBGS. Water resources were confiscated for the benefit of the Israeli settlements in the Ghor. Palestinian irrigation pumps on the Jordan River were destroyed or confiscated after the 1967 war and Palestinians are not allowed to use water from the Jordan River system. In other zones, the Israeli authorities introduced quotas on existing irrigation wells to restrict the amount of water pumped from these wells. Furthermore, the authorities did not allow any new irrigation wells to be drilled by Palestinian farmers, while it provided fresh water and allowed drilling wells for irrigation purposes at the Jewish settlements in the West Bank and Gaza Strip. In 1993, the "Declaration of Principles on Interim Self-Government Arrangements" was signed between Palestinians and Israelis, which called for Palestinian autonomy and the removal of Israeli military forces from the Gaza Strip and Jericho. Among other issues, this bilateral agreement called for the creation of a Palestinian Water Administration Authority and cooperation in the field of water, including a Water Development Program prepared by experts from both sides. In September 1995, the "Israeli-Palestinian Interim Agreement on the West Bank and the Gaza Strip", commonly referred to as "Oslo II", was signed. The question of water rights was one of the most difficult to negotiate, with a final agreement postponed to be included in the negotiations for final status arrangements. However a significant compromise was achieved between the two sides: Israel recognized Palestinian water rights (during the interim period a quantity of 70-80 million m³ should be made available to the Palestinians), and a Joint Water Committee was established to cooperatively manage West Bank water and to develop new supplies. This Committee also supervises joint patrols to investigate illegal water withdrawals. No territory whatsoever was identified as being necessary for Israeli annexation due to access to water resources (Wolf, 1996). In 2003, the Roadmap for Peace, developed by the United States, in cooperation with

Russia, the European Union, and the United Nations (the Quartet), was presented to Israel and the Palestinian Authority, with the purpose of a final and comprehensive settlement of the Israel-Palestinian conflict.

In 1999, and due to drought, Israel decided to reduce the quantity of water piped to Jordan by 60 percent which led to a sharp response from Jordan. Disputes of this kind are not unexpected in the future; however, the peace agreements have had the benefit of restricting such conflicts to political rather than military solutions. The fact that the joint water commission for Israel and the Palestinian Authority has continued to meet to discuss critical issues even during the current period of hostilities illustrates the progress that has already been made (Green Cross Italy, 2006).

In 2002, the water resources of the Hasbani basin became a source of mounting tension between Lebanon and Israel, when Lebanon announced the construction of a new pumping station at the Wazzani springs. The springs feed the Hasbani River, which rises in the south of Lebanon and crosses the frontier to feed the Jordan and subsequently the Sea of Galilee, which is used as Israel's main reservoir. The pumping station was completed in October 2002. Its purpose was to provide drinking water and irrigation to some sixty villages on the Lebanese side of the Blue line. October 2002 also marked the high point of tension between Israel and Lebanon, with a real risk of armed conflict over the station. The Israelis complained about the lack of prior consultation whereas the Lebanese contended that the project was consistent with the 1955 Johnston Plan on the water resources of the region. The EU and USA both sent envoys to the region in late 2002 in response to the rising tensions (EU, 2004).

In 2008, negotiations between Israel and the Syrian Arab Republic were taking place with the objective of solving the Golan Heights conflict.

IRRIGATION AND DRAINAGE DEVELOPMENT

Evolution of irrigation development

Since the early 1950s, intensive efforts have been invested in irrigation research. It was found that water use is much more efficient in pressurized irrigation than in surface irrigation. An irrigation equipment industry was established, mainly in kibbutzim, which developed innovative technologies and accessories such as drip irrigation (surface and subsurface), automatic valves and controllers, media and automatic filtration, low-discharge sprayers and mini-sprinklers, compensated drippers and sprinklers. Most of the irrigation is controlled by automatic valves and computerized controllers. Due to the division into plots and the harsh topographical conditions, only limited areas can be irrigated by mechanized systems, such as pivot irrigation. The innovative irrigation industry has a worldwide reputation and more than 80 percent of its production is exported.

In 2004, 225 000 ha were equipped for irrigation in Israel and localized irrigation (mostly drip irrigation) supplies over 75 percent of the total irrigated area (Table 5, Table 6 and Figure 3). Over the past fifty years, the average annual water application per hectare has decreased from 8 000 m³ to 5 000 m³, while agriculture has spread to the more arid regions in the south and east.

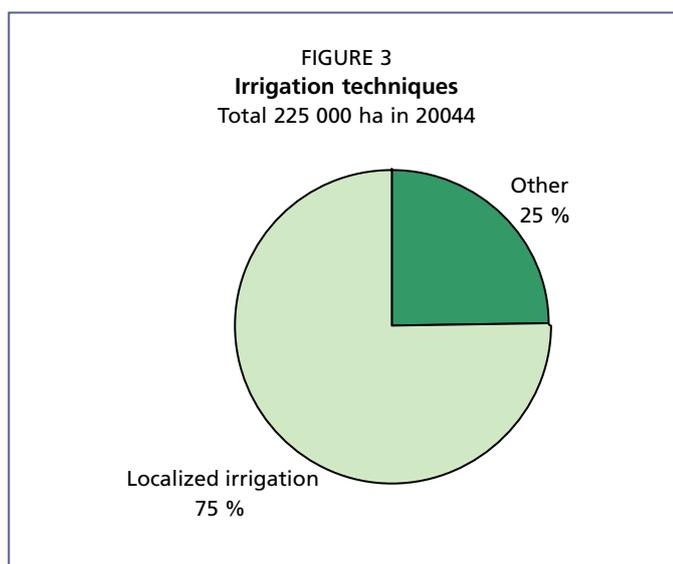


TABLE 5
Irrigation and drainage

| Irrigation potential | | - | ha |
|--|------------------|----------------|-------------|
| Irrigation | | | |
| 1. Full or partial control irrigation: equipped area | 2004 | 225 000 | ha |
| - surface irrigation | | - | ha |
| - sprinkler irrigation | | - | ha |
| - localized irrigation | 2004 | 168 750 | ha |
| • % of area irrigated from surface water | | - | % |
| • % of area irrigated from groundwater | | - | % |
| • % of area irrigated from mixed surface water and groundwater | | - | % |
| • % of area irrigated from mixed non-conventional sources of water | | - | % |
| • area equipped for full or partial control irrigation actually irrigated | | - | ha |
| - as % of full/partial control area equipped | | - | % |
| 2. Equipped lowlands (wetland, ivb, flood plains, mangroves) | | - | ha |
| 3. Spate irrigation | | - | ha |
| Total area equipped for irrigation (1+2+3) | 2004 | 225 000 | ha |
| • as % of cultivated area | | 57 | % |
| • % of total area equipped for irrigation actually irrigated | | - | % |
| • average increase per year over the last 7 years | 1997-2004 | 2.1 | % |
| • power irrigated area as % of total area equipped | | - | % |
| 4. Non-equipped cultivated wetlands and inland valley bottoms | | - | ha |
| 5. Non-equipped flood recession cropping area | | - | ha |
| Total water-managed area (1+2+3+4+5) | 2004 | 225 000 | ha |
| - as % of cultivated area | | 57 | % |
| Full or partial control irrigation schemes | | | |
| | Criteria: | | |
| Small-scale schemes | < ha | - | ha |
| Medium-scale schemes | | - | ha |
| large-scale schemes | > ha | - | ha |
| Total number of households in irrigation | | - | |
| Irrigated crops in full or partial control irrigation schemes | | | |
| Total irrigated grain production (wheat and barley) | | - | metric tons |
| - as % of total grain production | | - | % |
| Harvested crops | | | |
| Total harvested irrigated cropped area | 2002 | 181 570 | ha |
| • Annual crops: total | 2000 | 117 190 | ha |
| - Field crops | 2000 | 64 030 | ha |
| - Vegetables (including potatoes) | 2000 | 37 670 | ha |
| - Melons | 2000 | 10 060 | ha |
| - Cotton | 2000 | 11 000 | |
| - Chickpeas | 2000 | 7 500 | |
| - Flowers (including garden plants) | 2000 | 5 430 | ha |
| • Permanent crops: total | 2000 | 73 060 | ha |
| Irrigated cropping intensity (on full/partial control area actually irrigated) | | - | % |
| Drainage – Environment | | | |
| Total drained area | 1987 | 100 000 | ha |
| - part of the area equipped for irrigation drained | 1987 | 100 000 | ha |
| - other drained area (non-irrigated) | 1987 | 0 | ha |
| • drained area as % of cultivated area | | - | % |
| Flood-protected areas | | - | ha |
| Area salinized by irrigation | 1993 | 27 820 | ha |
| Population affected by water-related diseases | | - | inhabitants |

Production under protected conditions (obviously 100 percent irrigated) has become the principal way for Israeli growers to ensure a constant, year-round supply of high quality products, while minimizing chemical use. The total area covered with greenhouses, shade-houses and walk-in tunnels increased from 900 ha in the 1980s

TABLE 6
Use of land and water in agricultural production (MARD, 2004)

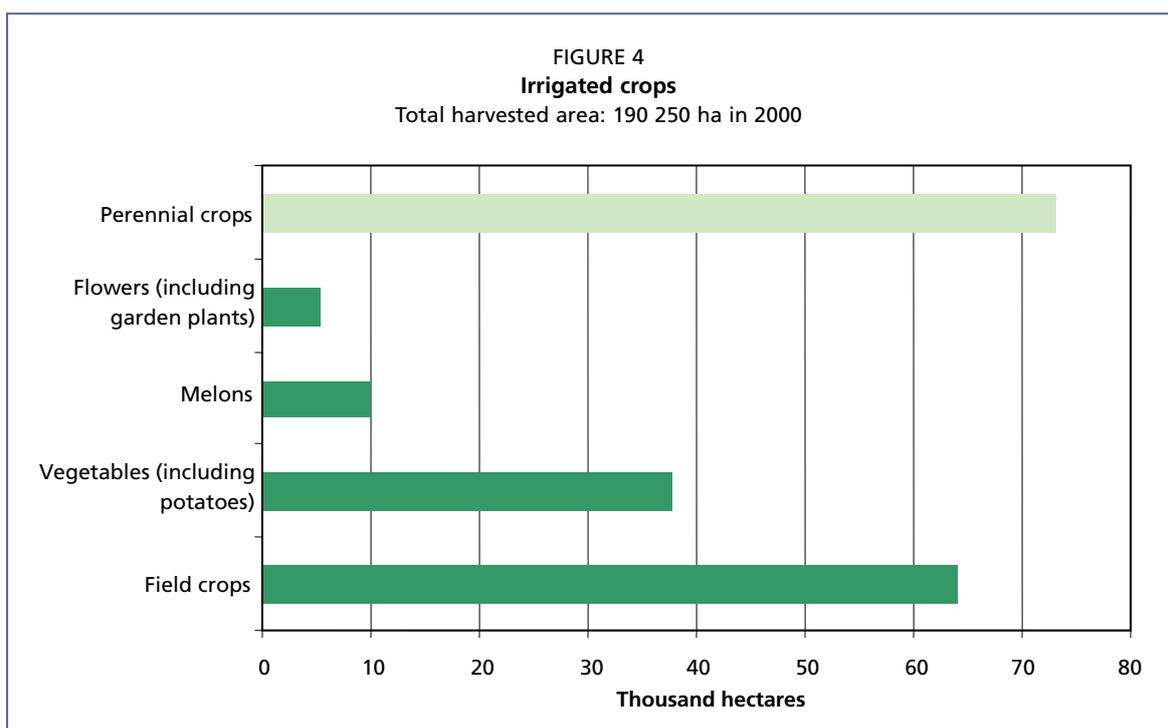
| | Unit | 1949 | 1970 | 1997 | 2001 | 2004 |
|----------------------------------|--------------------------------|------|-------|-------|-------|-------|
| Total cultivated land | 1 000 ha | 165 | 411 | 410 | - | 380 |
| Cultivated land under irrigation | 1 000 ha | 30 | 172 | 194 | - | 225 |
| Water consumption | 10 ⁶ m ³ | 257 | 1 340 | 1 287 | 1 021 | 1 129 |
| Potable water | 10 ⁶ m ³ | - | - | - | 563 | 601 |
| Recycled and brackish water | 10 ⁶ m ³ | - | - | - | 458 | 527 |

to about 6 800 ha in 2005, with 4 000 ha for vegetables and 2 800 ha for floriculture, representing an average annual growth of 5 to 8 percent. The average farm size is 4 ha for vegetable production and 1.2 ha for flower production (MARD, 2006).

Role of irrigation in agricultural production, the economy and society

In 2002, the total harvested irrigated area was 181 570 ha. In 2000, the harvested irrigated area was 190 250 and consisted of permanent crops (38 percent), field crops (34 percent), vegetables (20 percent including potatoes), melons (5 percent), and flowers (3 percent including garden plants) (Table 5, Table 7 and Figure 4).

Crops like flowers, vegetables and permanent crops are predominantly irrigated while 65 percent of field crops are rainfed. The main field crop is winter wheat but it is largely a non-irrigated crop, and therefore yields are dependent on the amount of rainfall and its distribution throughout the winter months. Wheat for grain is mostly grown in the country's dry southern regions and the north-eastern interior valleys, enabling extensive use of agricultural land. Almost the entire 11 000 ha of the cotton crop is drip-irrigated with Israeli-made equipment. Cotton yields per land unit are among the highest in the world, averaging 5.8 tonnes/ha for raw Acala cotton, with 2.0 tonnes of fibre, and 5.3 tonnes/ha for raw Pima cotton, with 1.8 tonnes of fibre. The cotton sector is totally mechanized. The introduction of effluents for irrigation has contributed to a significant reduction in growing costs. Moreover most sunflower crops are drip-irrigated, achieving significant savings in water: 1 800-2 500 m³ of water



are sufficient to produce two to 3 tonnes/ha. About 7 500 ha of irrigated chickpeas are grown and achieved a yield of 3 tonnes/ha in 2004-2005 (MARD, 2006).

Gross investments in farms amounted to US\$500 million in 2004, of which 1 percent was devoted to irrigation systems (Table 8). Moreover, this sector represented 3 percent of the total net capital stock in farms (Table 9).

TABLE 7
Area of Field Crops, Vegetables, Potatoes and Melons in thousand hectares (CBS, 2006)

| | 2000 | 1999 | 1998 | 1995 | 1990 | 1980 | 1970 |
|--------------------------------------|--------|--------|--------|--------|--------|--------|--------|
| Field crops – Total | 184.96 | 182.49 | 218.02 | 218.45 | 219.55 | 259.26 | 251.78 |
| - Irrigated | 64.03 | 69.57 | 83.41 | 79.75 | 90.37 | 76.76 | 63.73 |
| - Rainfed | 120.93 | 112.92 | 134.61 | 138.70 | 129.18 | 182.50 | 188.05 |
| Vegetables, Potatoes, Melons - Total | 55.11 | 55.54 | 53.76 | 55.83 | 46.07 | 35.52 | 34.57 |
| Vegetables – Total | 26.98 | 27.40 | 25.43 | 26.94 | 25.80 | 22.28 | 19.93 |
| Potatoes – Total | 11.29 | 10.61 | 8.95 | 8.12 | 6.25 | 5.02 | 4.83 |
| Melons – Total | 16.84 | 17.53 | 19.38 | 20.77 | 14.02 | 8.22 | 9.81 |
| Watermelons: not irrigated | 6.27 | 6.55 | 10.29 | 11.66 | 4.81 | 3.11 | 5.49 |
| Watermelons: irrigated | 7.10 | 7.68 | 6.29 | 5.45 | 4.52 | 2.13 | 2.10 |
| Melons: not irrigated | 0.51 | 0.56 | 0.78 | 1.47 | 1.64 | 1.12 | 1.58 |
| Melons: irrigated | 2.96 | 2.74 | 2.02 | 2.19 | 3.05 | 1.86 | 0.64 |

TABLE 8
Gross investments in farms (\$US million, at current prices), by type of asset (CBS, 2006)

| | 2005 | 2004 | 2003 | 2000 |
|--|--------|--------|--------|--------|
| GROSS INVESTMENT - TOTAL | 470.48 | 450.15 | 375.65 | 375.21 |
| Fruit plantations | 60.30 | 57.56 | 52.57 | 61.94 |
| Livestock (1) | 6.74 | 5.92 | 9.35 | 11.62 |
| Agricultural equipment and machinery (2) | 247.34 | 251.08 | 193.08 | 180.73 |
| Agricultural structures | 125.90 | 96.19 | 70.37 | 39.73 |
| Irrigation systems | 4.60 | 4.68 | 4.86 | 8.34 |
| Greenhouses (3) | 13.25 | 10.47 | 11.00 | 41.98 |
| Fish ponds/industrialized fishery | 0.59 | 5.70 | 2.22 | 0.54 |
| Land reclamation and drainage | 11.76 | 18.55 | 32.20 | 30.33 |

1. Changes in livestock inventory, not in investment
2. Includes commercial vehicles over 4 tonnes
3. The investment is calculated according to changes in their area

TABLE 9
Capital stocks in farms (\$US million, at 2000 prices), by type of asset (CBS, 2006)

| | 2005 | 2004 | 2003 | 2000 |
|--------------------------------------|----------------|----------------|----------------|----------------|
| Gross Capital Stock TOTAL | 4281.26 | 4300.74 | 4446.92 | 4587.06 |
| Fruit plantations | 837.15 | 838.42 | 855.57 | 835.27 |
| Livestock | 292.95 | 292.01 | 294.21 | 303.29 |
| Agricultural equipment and machinery | 1313.63 | 1292.58 | 1330.59 | 1287.65 |
| Agricultural structures | 1017.84 | 1008.70 | 1027.17 | 1134.76 |
| Irrigation systems | 147.73 | 177.58 | 223.36 | 311.43 |
| Greenhouses | 105.58 | 115.37 | 125.35 | 108.98 |
| Fish ponds | 135.91 | 138.06 | 147.27 | 173.27 |
| Land reclamation and drainage | 430.48 | 438.04 | 443.40 | 432.42 |
| Net Capital Stock TOTAL | 2196.96 | 2177.69 | 2239.11 | 2293.00 |
| Fruit plantations | 404.44 | 399.47 | 406.50 | 389.75 |
| Livestock | 292.95 | 292.01 | 294.21 | 303.29 |
| Agricultural equipment and machinery | 608.23 | 581.99 | 601.25 | 585.90 |
| Agricultural structures | 531.96 | 513.57 | 510.67 | 521.95 |
| Irrigation systems | 56.12 | 60.54 | 67.82 | 95.07 |
| Greenhouses | 35.89 | 44.11 | 53.59 | 51.08 |
| Fish ponds | 54.21 | 57.29 | 64.88 | 89.97 |
| Land reclamation and drainage | 213.16 | 228.70 | 240.18 | 255.99 |

Status and evolution of drainage systems

In 1987, the area equipped for irrigation drained was estimated at around 100 000 ha (Table 5), of which 94 000 ha of surface drainage and 6 000 ha of horizontal sub-surface drainage. In 1993, the area salinized by irrigation was 27 820 ha (ICID, 2007).

In 2004, land reclamation and drainage represented 4 percent of the gross investments and 10.5 percent of the total net capital stock in farms (CBS, 2006).

WATER MANAGEMENT, POLICIES AND LEGISLATION RELATED TO WATER USE IN AGRICULTURE

Institutions

The Water Commission, previously under the Ministry of Agriculture and Rural Development (MARD) but now under the Ministry of National Infrastructures (MNI), implements the water law, plans, develops, allocates, and manages water, and sets and annually revises water prices with the approval of a special parliamentary committee. Apart from the MARD and MNI, the Ministry of Finance (MOF) and the Ministry of Industry, Trade and Labour (MITL) also have a strong influence on the water sector. At the operational level, the Water Commission relies on Mekorot, a state-owned water company that produces and distributes around 70 percent of the water supply in the country. Mekorot operates the National Water Carrier, the pipeline system that moves water southwards from Lake Galilee to the Negev desert. In recent years, Mekorot has also entered spheres such as urban water retail, sewerage treatment, and sea water desalination. The Water Commission receives technical planning as well as research and development support from Tahal, a large engineering consulting firm. Although this firm had been the official and sole water planner for the past 20 years or so, now it is made to compete with other engineering companies within Israel to obtain project contracts from government (World Bank, 1999).

The Agricultural Extension Service of MARD focuses on all subjects related to agriculture, in particular water management, the promotion of water saving technologies and use of marginal water. It is financed by two sources: government funds (80 percent) and non-government sources, mainly production and marketing boards (20 percent). Generally services to farmers are free, although some supplementary advisory packages are provided upon specific request in exchange for payment.

The Ministry of Health (MOH) is responsible for the quality of drinking water in Israel. In order to assure water quality, the Ministry has promulgated regulations that specify water quality standards regarding its microbial, chemical, physical and radiological aspects.

The Yigal Allon Kinneret Limnological Laboratory (Israel Oceanographic and Limnological Research) carries out research aimed at understanding how present and future conditions might influence water quality and monitors major environmental factors which may affect the state of Lake Kinneret (Lake Tiberias).

Water management

Water is regarded as a national asset and is protected by law. Users receive their annual allocation from the Water Commission. The entire water supply is measured and payment is calculated according to consumption and water quality. Urban users pay much higher fees for water than farmers, including a water reclamation levy. Farmers pay differential prices for potable water. The first 60 percent of the allocation costs 20 cents per m³, 60 percent to 80 percent costs 25 cents, and 80 percent to 100 percent costs 30 cents per m³. This incremental price policy encourages water saving. Water scarcity and price policy necessitate the use of marginal water, such as brackish and reclaimed water. Brackish water is used for irrigation of salinity-tolerant crops like cotton. In several crops, such as tomatoes and melons, brackish water improves produce quality although lower yields are achieved. The use of reclaimed water for irrigation of edible

crops requires a high level of purification. For that purpose, unique technology – Soil Aquifer Treatment (SAT) – is now being applied in the densely populated Dan region. After tertiary purification, the water percolates through sand layers, which serve as a biological filter, into the aquifer. From there it is pumped at nearly potable quality and can be used for unrestricted irrigation (MARD, 2006).

Groundwater and surface water are state property according to the Israel water law. Each year the Israel water commissioner allocates for each village an annual water quota for irrigation. Historically, initial quotas were determined according to factors such as: total land suitable for irrigation, soil type, population size, location, water usage prior to 1959 and political affiliation of the village. Water quotas are adjusted periodically in order to take into consideration new water sources and new villages. The price of water is determined by the commissioner using a three-tier price system. These price levels are determined according to historical quotas. Thus, the allotment of irrigation water and water prices are assumed to be exogenous to the farmers (World Bank, 2007).

Finances

Although water policy and administration are centralized with considerable political overtones, the water sector in Israel is subject to a much stronger economic influence than its counterparts in other countries. This is partly due to metered volumetric allocation and partly due to a relatively stricter economic water pricing system. While inter-sectoral water allocation is used to favour domestic and industrial sectors, water prices in these sectors are higher and cover full costs. Even though irrigation water is subsidized, the subsidy has declined from 75 to 50 percent since progressive block rate pricing was introduced in 1987 that penalizes large and fresh water consumers. Water wastage is the least in all sectors and water productivity has increased more than 250 percent in agriculture and 80 percent in industry (World Bank, 1999).

Policies and legislation

The 1959 Water Law that made water a nationalized public good remains the foundation for present water policy and water administration. According to that Law, all water is the property of the state, including waste, sewer and runoff water that can be used commercially. A landowner does not own the water under his/her land. The Law also created a permanent body known as the Water Commissioner (see above) to oversee and allocate water rights.

Israel's Water Law includes sewage water in its definition of "water resources." National policy calls for the gradual replacement of freshwater allocations to agriculture by reclaimed effluents. In the year 2002, treated wastewater constituted about 24 percent of consumption by the agricultural sector. It is estimated that effluents will constitute more than 40 percent of the water supplied to agriculture in 2010 (CBS, 2006).

ENVIRONMENT AND HEALTH

Israel's current water crisis is the result of both natural conditions (climate, geography and hydrology) and human activity. Natural constraints are exacerbated by anthropogenic impacts. Overpumping from aquifers to meet growing demands has led to the infiltration of seawater and salinity, the impoundment of springs has dried up perennial and ephemeral streams, and domestic, industrial and agricultural practices have contaminated water sources. The quality of the country's main water sources has been increasingly endangered by pollutant discharges from different sectors:

- The Coastal Aquifer is seriously threatened by chemical and microbial pollutants, salination, nitrates, heavy metals, fuels and toxic organic compounds. According to the most recent report of the Hydrological Service, about 15 percent of the total amount of water pumped from the Coastal Aquifer does not comply with existing drinking water standards for chloride and nitrate concentrations. Average chloride

concentrations in the coastal aquifer are increasing at an average rate of 2 mg/l per year, reaching an average of 195 mg/l in 2002/03. Chloride concentrations below 250 mg/l and nitrate concentrations under 45 mg/l exist in only 50 percent of the water which is drawn from wells in the coastal basin. These concentrations are unsuitable for unrestricted agricultural irrigation. Nitrate concentrations in the Coastal Aquifer have increased considerably due to intensive use of fertilizers in agriculture and use of treated effluents for irrigation. Since 1950, average nitrate concentrations have increased from 30 mg/l to 63 mg/l today, with an annual rate of increase of about 0.6 mg/l. Concentrations exceeding 70 mg/l were measured in traditional agricultural areas in the centre of the country.

- Because of the deterioration in both the quantity and quality of the water in the Coastal Aquifer, the Yarkon-Taninim Aquifer is becoming a main supplier of drinking water in the country. Water levels in this aquifer have decreased while a gradual increase in chlorides has been noted over the years. This deep limestone aquifer is especially prone to contamination due to its karstic nature and the quick transit of pollutants through it. Overexploitation may lead to a rapid rate of saline water infiltration from surrounding saline water sources.
- Due to the continuous drop in water levels in Lake Tiberias since 1996, regulations have lowered the minimum “red line” from 213 meters below sea level to minus 215.5 meters in 2001. The risks associated with reduced water levels are enormous: ecosystem instability and deterioration of water quality, damage to nature and landscape assets, receding shorelines and adverse impacts on tourism and recreation. Salinity in the lake has been alleviated by diverting several major saline inputs at the northwest shore of the lake into a “salt water canal” leading to the southern Jordan River. This canal removes about 70 000 tonnes of salt (and 20 million m³ of water) from the lake each year. The salt water canal is also used to remove treated sewage from Tiberias and other local authorities along the western shoreline away from Lake Tiberias and into the Lower Jordan River. In the catchment area, a concerted effort has been made to lower the nutrient load by changing agricultural and irrigation practices, by cutting back the acreage of commercial fishponds and by introducing new management techniques. Sewage treatment plants were improved and a new drainage network that recycles most of the polluted water within the watershed was constructed. Around the lake, public and private beaches and recreation areas with appropriate sanitary facilities were developed. Pollution and sewage from settlements and fishponds near the shores were treated and diverted from the lake. Next year, Mekorot, the national water company, will begin to operate a purification plant which will filter the water pumped from the Lake Tiberias and will allow Israel to comply with water turbidity standards set by the Ministry of Health.

The Dead Sea, located in the Syrian-African Rift Valley, is the lowest place on earth (416 meters below sea level). It is also the world's saltiest large water body, with a salt concentration ten times higher than that of the Mediterranean Sea. The Dead Sea has been threatened since the mid-twentieth century by declining water levels, at a rate of over one meter per year. Over the past 30 years, the Dead Sea has lost some 25 meters, mainly because water which previously fed into the Dead Sea is now diverted from the Sea of Galilee and the Yarmouk River to supply fresh water to Israel, Jordan and the Syrian Arab Republic. Furthermore, Dead Sea brine is withdrawn from the Dead Sea to supply the potash industries in Israel and Jordan. This negative water balance, which is expected to increase in the future, has a significant impact on existing and future infrastructure and development plans, natural and landscape values, the image of the region and the lives of local residents (MOE, 2004).

In 2004 an important amendment to the 1959 Water Law was passed, integrating nature's right to water and legitimizing this right statutorily. The Water Commission

took a decision to allocate 50 million m³ per year of freshwater to nature rehabilitation in the future. However, until this commitment is realized, there is no choice but to discharge surplus high quality effluents into rivers and wetlands (MOE, 2005b).

PROSPECTS FOR AGRICULTURAL WATER MANAGEMENT

To reduce water demand and increase water supply, in July 2000 and in April 2001 the Ministerial Economic and Social Committee, headed by the Prime Minister, took among others the decisions to:

- Take steps to increase the efficiency of use and savings with the object of reaching additional savings of 200 million m³ of freshwater per year for the next three years—half from municipal consumption and half from agricultural consumption;
- Establish plants for water desalination at a production capacity of 200 million m³ with supply to start in 2004;
- Prepare a programme for the desalination of brackish water with an objective of 50 million m³ over the next three years;
- Allocate 50 million m³ of water for the conservation of nature;
- Remove obstacles to effluent reuse and advance plans for upgrading effluent quality to allow maximum use of effluents in agriculture, industry, nature and landscape, without harming the environment and groundwater;
- Reclaim contaminated wells and increase production and transport capacity;
- Contract a private developer for the supply of water from the deep-water aquifer in Mishor Rotem at a rate of 30 million m³ per year;
- Increase water tariffs in order to reduce water demand for municipal gardening, home gardening, the domestic sector and the agricultural sector;
- Promulgate regulations on water savings in the urban sector including water-saving devices, car washing, facilities for water recycling, cooling towers, etc;
- Continue the public information campaign on water conservation until 2003;
- Establish an inter-ministerial team under the director general of the Prime Minister's Office for coordination and control purposes.

While Israel has one of the best performing water sectors in the world, it still faces crucial challenges most of which are characteristic of a mature water economy operating in an acute water stress condition. These challenges include:

- Addressing the potential side-effects for increasing brackish water and wastewater use in agriculture (e.g., groundwater contamination, soil salinity, and health hazards);
- Allowing and facilitating the exchange of water permits to promote market-based water allocation and compensation;
- Redefining the role of public agencies to avoid centralization and permit private sector participation;
- Making the Water Commission free from political pressures and rebuilding its own planning and regulatory capabilities;
- Building consensus on crucial areas of disagreement (e.g., supply augmentation through water transfers from Lebanon and Turkey and sea water desalination, installing national/regional carriers for saline/waste water collection and distribution, and decentralization and privatization of Mekorot); and
- Sharing water with Jordan and the Palestinian Authority and creating institutional structures for the joint management of shared groundwater aquifers.

The first three issues were addressed by the 1997 report of the Public Commission on Water Sector. With an already exhausted freshwater supply, an estimated future annual growth in water demand of 30 million m³ means the inevitable need for costly options like sea water desalination (World Bank, 1999).

A study based on a Ricardian model tested the relationship between annual net revenues and climate across Israeli farms. Including the amount of irrigation water available to each farm, the model predicts that only modest climate changes are beneficial while drastic climate change in the long run will be harmful. Using the Atmospheric Oceanic Global Circulation Models Scenarios it was shown that farm net revenue was expected to increase by 16 percent in 2020 while in 2100 farm net revenue was expected to drop by 60 percent to 39 percent varying between the different scenarios. Although Israel has a relatively warm climate, a mild increase in temperature is beneficial due to the ability to supply international markets with farm products early in the season (World Bank, 2007).

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