DROUGHT AND ARID LAND WATER MANAGEMENT

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1. Overview

The Situation

The challenge of sustainable water management in semi-arid countries like Israel is magnified by the country's geography, hydrology, climate and trans-boundary issues. The country is divided into semi-arid, arid or hyper-arid regions with at least six rainless months per year. Rainfall variations occur from year to year, with periods of multi-year droughts or near droughts interspersed with periods of heavy rainfall.

Israel has only three main sources of renewable fresh water. The Sea of Galilee (Lake Kinneret) is the sole natural surface reservoir located in the north of Israel. Annual rainfall averages 800 mm/year in the north and 400 mm/year in the center, which percolates down to the Mountain and Coastal Aquifers that are tapped by wells. Average rainfall in the south ranges between 0-100 mm/year. Brackish water in the southern and eastern valleys is utilized for salt-tolerant agriculture or desalinated. Further complicating Israel's water issues are year-round high levels of solar radiation causing significant surface evapotranspiration, as well as the loess soil of the southern Negev desert, whose crust resists absorption of rainfall and runoff.

Water scarcity has been of concern to Israel since its establishment in 1948. A tenfold increase in population coupled with extensive industrial growth and economic development have placed a continuous and growing demand on Israel's limited water resources. Climatic fluctuations accentuated by periodic drought, affect water availability while sectorial pressures from urban development, heavy industries and agricultural fertilizers and pesticides degrade available water quality.

Israel's 'Mekorot' national water supply utility, a government company operating under the regulation of the Water Authority, supplies approximately 67% of Israel's potable water while the remaining ground water is pumped privately. Total demand per year was 1959 MCM (Million Cubic Meters) (2006); 58% for agriculture, 36% for domestic use and 6% for industry. Some 30% of agricultural water is treated wastewater used for drip irrigation of orchards and non-food crops.

The Crises

Israel has suffered from a chronic water shortage for years. By the mid-1990s, after several multi-year cycles of drought and over-pumping of natural water reservoirs, the situation developed into a crisis so severe that an adequate supply of domestic water was in jeopardy. The current cumulative deficit in Israel's renewable water resources, according to the Hydrologic Service, amounts to approximately 1 billion cubic meters (1000 MCM), which is half of country's annual consumption. The deficit has also led to the qualitative deterioration of potable aquifer water resources that have either become of brackish quality or otherwise polluted especially the coastal aquifer ground water, which is the only multi-year groundwater reservoir.

The causes of the crisis are both natural and man-made, intensified by several years of drought. The increase in demand for water for domestic uses, caused by population growth and the rising standard of living, has led to over-utilization of its renewable water sources. Israel's water sector is experiencing the costs associated with a highly urbanized and industrialized economy. These include urban development that impedes natural recharge of the aquifers from rainfall and the "traditional" pollution caused by industries, trans-boundary sewage and the highly industrialized agricultural sector.

Israel's water economy is also affected by its shared ecosystem, climate and limited water sources with its neighbors. The challenge of managing trans-boundary resources is not limited to Israel's obligatory water allocations governed by treaties. It also extends to sustainable management of shared surface and groundwater resources and the prevention of pollution.

Existing groundwater resources are being degraded by seawater intrusion, as over-extraction lowers the water table, while man-made pollution is a continuous threat. However, significant amounts of sewage water are treated (92%) and recycled (75%), primarily for agricultural use.

The policy for the water sector, particularly in the past decade, combined with the absence of adequate action facing the impending water shortage situation, has contributed to the severity of the crisis.

The Response

The crisis led to the realization that a national master plan for policy, institutional and technological changes is required to stabilize the situation and to manage its water sector more efficiently with a long-term perspective. The main points of the plan are:

- Moving from a policy based on "brinkmanship" to a sustainable policy
- Reclamation of large amounts of effluents
- Water saving projects
- Sea water and brackish water desalination plants
- Organizational change

Until 2007, water management in Israel was divided among seven government ministries, which hampered efficient management, planning and development. To alleviate the situation a new Water Authority was finally established in 2007 with most responsibilities centralized under one administrative roof (the process will be finished by 2010). The authority provides a new opportunity for effective cooperation among the various governmental offices, non-governmental organizations, the private sector and citizens and a vastly improved chance for sustainable development of the water ecosystem. The Authority is also responsible for setting tariffs and not just for the development and operation of the water sector. On top of that the authority will be responsible for the entire water chain from pumping, to sewage treatment and then reclamation.

Israel's sophisticated and developed economy correlates with increasing standards of living and hence with an increasing demand for higher water quality and reliability by its 7.2 million residents (2007), although per capita urban water consumption has changed little in the past 40 years. Having an advanced public and private research and development sector helps Israel to arrive at technological and economical solutions in the fields of water production and water treatment (e.g., recycling and treatment facilities).

In addition to technologically intensive solutions, significant efforts are being made – according to sustainable development guidelines and legislation – to maximize the utilization of existing water resources. This entails improved public water conservation and the restructuring of water rates that reflect water supply costs, including scarcity on the one hand, and upgrading sewage treatment on the other. To maximize safety and minimize environmental risk from wastewater reuse, water quality standards are being upgraded (approved by the Water Authority council in 2007) for both agricultural use of treated wastewater and its discharge into aquifers, streams and rivers.

Increased water conservation and water use efficiency remain the most cost effective priority for supplying water. However, it became clear to the Water Commission (Water Authority) that the available water sources could not meet demand. The time had come to introduce and integrate large-scale seawater desalination plants into the country's water supply system coupled with improved demand management tools. Due to the fact that Israel has a relatively long coastline and a well-developed economy, seawater desalination is a cost effective option compared to other water supply options.

2. Concrete Actions and Specific Programs

2.1 Strategic Planning – Restructuring the Water Sector

In recent years, the rationale motivating the water sector in Israel has undergone changes integrating economic incentives and environmental and health considerations to become more efficient and responsible for future generations.

The changes reflect significant gaps in water supply but also indicate a dynamic approach to deal with the climatic uncertainty and the threat of drought by disseminating new water production technologies, water treatment and advanced management tools. The program to develop additional water supplies is aimed to address extreme decreases in the replenishment of natural sources. For example, the national desalination plan (505 MCM by 2013) is based upon a 10% drop in average multi-year replenishment with the need to address consecutive years of drought.

Israel's notable achievements in the last few years include: desalination, increased treatment and recycling of wastewater, improved standards for drinking water, updated water rates for all sectors, water saving campaigns, introducing demand management tools (for example, production levies) and new water infrastructure and technology projects. In addition, for the first time, nature and ecosystems were accorded standing as a "consumer" (like agriculture) according to the national master plan, with a targeted allocation for main water ecosystems.

All activities in the water sector will be based on a new water sector policy that incorporates a development plan and is founded upon three basic components: ensuring water supply, social and economic requirements, environmental and ecological needs, and based on the Israeli Government's decision on a sustainable development program in the areas of water and sewage.

2.2 Improving Water Demand Management Policies

2.2.1 Structure of Water Pricing

Water in Israel is metered and charged according to volume use. Pricing structure has changed in the late 1980's as part of a new water demand policy to an increasing block tariff that is intended to achieve efficient patterns of water-use. Currently, water prices for users vary widely across and sectors and regions in three ways: 1) agricultural users pay lower prices than industrial users who pay lower prices than households; 2) prices differ among regions in ways that are not always inconsistent with water transportation costs; and 3) consumers face an increasing block-rate pricing structure whereby higher prices are paid for higher levels of consumption.

Beginning in 2007, as part of a new arrangement of the water sector, the national water regulator Water Authority was established, with expanded responsibilities including control over tariffs. One of the key demand-management tools is the Extraction Levy on water producers. The extraction levy reflects scarcity in water resources and together with the production and distribution costs, it is possible to set water prices such that they reflect the true value of water. The economic goals of the extraction levy are as follows:

- **Agriculture –** encourage farmers to switch to recycled water or main supply system (the National Water Carrier), thereby utilizing the nation's water resources more efficiently, creating tools to manage overall water production using economic incentives, creating tools for regional management of water quantity and water scarcity, encouraging the development of new water sources and agricultural preservation and the preservation of nature and landscape.
- **Domestic and industry –** use economic incentives to encourage water-producing municipalities to connect to the national water network to maximize aquifer rehabilitation and utilization and to aid water supply and quality regulation.

2.2.2 Water for Agriculture

Agriculture has historically used around 70% of the water supply but use has been decreasing since the mid-1980. In recent years, the agricultural sector relies on 50% of its total demand for irrigation on recycled and saline water sources. Interestingly, decreased potable water demand for agriculture has been accompanied by a steady increase in the overall value of agricultural output.

During its first sixty years, while the country's population grew seven-fold, agricultural production expanded sixteen-fold. Water usage, however, did not increase. The invention and introduction of drip irrigation in Israel during the 1960s was the single most important innovation in local agricultural development.

The drought of the early 1990's suggests how more market forces may decrease agricultural demand for water without affecting production. Due to extended drought in the years 1990-91, the real price of water supplied to agriculture was increased by 47% and the supply quotas were reduced by more than 50% to deal with the shortage. However, although farmers were adversely affected in the short-run, they were able to adapt through substantial investment in highly efficient computerized and drip irrigation technologies that reduced their demand in the long run. Israeli agriculture reduced potable water consumption substantially over the years with no impact on production. For example, between the years 2000-2005, the fruit sector experienced an average to 35% cut in water quotas, but increased its production by 42%.

Additional agricultural assistance efforts to save water have focused on the removal of marginal plantations and replacing them with drought-resistant trees such as of olive and almond; water-conserving technologies; storm runoff collection; and technologies to improve the agro-technical, environmental and health concerns involved with the reuse of wastewater effluents.

2.2.3 Water for Domestic Use

Water for household users is delivered by municipalities or by newly established local Water Consortiums who buy at Mekorot-established prices or extract water locally, pay the government extraction levy and sell at higher prices to residents, which more than cover the costs of local water delivery. Water consumption is metered and users face increasing block rate pricing. All households face the same block rate tariff.

Household consumption of water in Israel has been growing at roughly 2.5% per year due to population growth and income growth. Per capita domestic water demand reflects a rise in the standard of living. In 1970, demand per capita was 79.3 MCM, 100 MCM in 1990, and 102.32 MCM in 2005. Domestic users, in general, are not generally influenced much by water prices and demand remains relatively inelastic when water prices increase. Although water-conserving ordinances are in place, they are rarely enforced unless a drought has been officially declared.

National water-conservation campaigns have proven to be effective in lowering consumption. These encourage efforts to fix leaks, utilize water-conserving faucets and dual-flush toilets, and promote arid landscape design and irrigation practices in private and public gardens. It is important to stress that a significant saving in the domestic sector has the potential of delaying costly investment in desalination plants.

Industry and agricultural water consumption patterns reflect their economic motivation. They operate in competitive local and international markets and are obligated to cut costs and improve efficiencies. This market mechanism is weak in the domestic sector, which includes municipalities. While the problems are not uniform among local municipalities, data indicate that there is an average of 10% water waste due to old and leaking infrastructure across a typical town's network and public institutions. The Transitional Master Plan of the Water Authority suggests that the urban sector can save 10% to 20% without effecting consumers' welfare. A saving of 15% in the domestic sector would easily postpone building of a desalination plant of a 100 MCM/yr capacity. This would require consumer and municipal water conservation efforts, including water conserving ordinances and their enforcement and implementation in the tourism sector where compliance is more easily attained.

2.2.4 Water Sensitive Planning (WaSP) to Harvest Urban Runoff

Urban runoff and storm water capture also provide multiple benefits in treating, restoring and recharging groundwater. The imperative of incorporating water considerations into urban and regional development, from the very outset of the planning process, is increasingly recognized and adopted by national authorities and municipal governments, and supported by NGOs. Government Statutory Master Plan (NOP 34B 2006/7) stipulates that the management and use of runoff must be in accordance with WaSP principles.

"Water Sensitive Planning (WaSP)" encompasses management of runoff as a resource (e.g., for direct use or groundwater augmentation) while protecting against the nuisance and damages of flooding. Implementation is based on Best Management Practice (BMP) methods for detention, retention and infiltration throughout the urban and regional watershed, in addition to water conservation and use of non-conventional sources (e.g., grey water) for increased water use efficiency. WaSP is a paradigm shift from the conventional concept of runoff as a nuisance to be removed and disposed of as quickly as possible, and redefines it as a valuable resource to be harvested by efficient channeling to surface or underground storage for future use.

2.2.5 Environmental Objectives in Water Policies

In recent years, environmental objectives and considerations are taken into account in water policies related to water allocation, pollution, drainage, and trans-boundary aspects.

Three environmental factors directly affected water resources and made them an essential part of any water management policies:

- Pollution of potable wells and the accompanying stress on water supplies
- Destruction of riparian ecosystems due to upstream diversion and the release of multiple sources of pollutants into the riverbed
- Lack of drainage management and its impact on runoff

The main **instruments** in water policies to ensure the health of water resources as well as the river ecosystems are:

- Formal riparian water allocations in the national water budget
- Stringent ordinances and enforcement against industrial, urban and agricultural polluters
- Rehabilitation of polluted aquifer and streams
- Monitoring budgets to eliminate pollution at the source
- Defining stream rehabilitation as the responsibility of the Drainage Authority.

The main **obstacles** to having better protection of the resources and of the aquatic ecosystems lay with financial, structural and technical factors such as:

- Lack of monitoring of point-source pollution and monitoring of non-point-sources pollution
- Need to enlist multiple sectors into protection of aquifers and other water sources from pollution (e.g., dairy farms)
- Lack of sufficient water supply for domestic, agricultural and industrial users and trans-boundary agreements prevent designated allocation to rivers and streams (50 MCM/yr)

Budget restrictions for establishing, rehabilitating and/or upgrading of sewage treatment plants and for enforcement of pollution ordinances are limited, creating additional obstacles in protecting water resources and aquatic ecosystems.

Objectives and measures that can be proposed for progress in the medium–long term in the policies relies on freeing up water quantities for the environment by increasing quantities of water production and recycled water and by reducing water consumption by promoting awareness and conservation. Such actions, including tight enforcement, require allocation of budgetary resources.

2.3 Water Demand Management (WDM) in Water Policies

Changes in water demand in Israel reflect a dynamic, rapidly developing, water sector that was challenged with a fast growing economy and an unexpected rapid population increase from immigration (32% increase between 1990 to 2000). The Israeli water economy reflects a strong ability to improve on all dimensions in order to supply water in demanded quantity, quality and reliability despite the uncertain planning environment.

The main trends possible for water demand by 2015/2025 relative to 2005 indicate great challenges for the economy to keep up with the forecasted overall demand for recycled water for the agricultural sector and fresh water for the urban sector (estimated at 25 MCM/year). The consequences and possible risks from such an increase in water demands include: major increase in water prices; inequality among users where ability to pay would grant higher water quality; increase in water funds for water-saving campaigns, a major scarcity should recycled water for irrigation be proved too risky for the environment; public health and agro-technical investments; increase in trans-boundary obligations; inability to meet riparian ecosystem requirements.

Objectives until 2015/2025 that were set in order to avoid crises are: conducting a water-saving pilot campaign among 1.5 million residential users, increasing water prices, increasing sewage levies (charged automatically per each unit of water consumed, not including water for gardening), imposing extraction levies on all water producers, privatizing the municipal water sector by establishing Water Consortiums, rehabilitating polluted portions of the coastal aquifer, diverting saline water from fresh sources, developing desalination plants, rehabilitation of streams and their ecology, investing in improving water quality at banned wells and collecting storm water.

Water policies have evolved from basic water supply management to a more balanced policy that integrates water demand. For example, the Transitional Master Plan includes chapters on water saving programs, recycling plants and other issues that support demand policies. Significant changes in approach, especially in water pricing, have been registered since the late 1980's following severe drought. At that time, increasing block tariffs for agriculture have been introduced in addition to the administrative quotas. Industrial prices were increased to almost equate water prices at the city entry point to the municipal system. Beginning in 2007, water producers are charged extraction levies and this step is expected to increase water prices to reflect water scarcity and hence the true value of water, which is now considered comparable to the price of desalinated water.

2.4 Resources, Mobilization and Alternative Water Production

2.4.1 Natural Water Resources

Most of the renewable water resources of Israel are regulated by natural groundwater reservoirs and by Israel's largest natural surface reservoir (Lake Kinneret). The multi-annual average replenishment of these resources is estimated at 1,840 MCM/yr, which is distributed among the country's surface and groundwater basins.

This yield is achieved by controlled outflows for salinity flushing, uncontrolled outflows to the Mediterranean and to the Dead Sea due to water table variations, releases to external trans-boundary users or direct use by such users. The natural groundwater resources also combine recharge of floodwater and return flows from irrigation to the Coastal Aquifer.

The following table shows Israel's total water demand (usage) for 2004.

Table 2.1: Israel's total water demand (usage) (MCM/year, Source: Water Authority, 2004)

Water Use	Quantity (MCM/year)
Water use from natural resources	1,670
Marginal water use (sewage effluents and floodwater)	384
Water supplied to Kingdom of Jordan and Palestinian Water Authority	100
Total (2004)	2,054

Production of Alternative Water

The main production facilities on which Israel relies to meet future increasing water demand are: seawater desalinization plants and increased wastewater treatment.

2.4.2 Sea-water Desalination Plants

The National Master Plan, originally launched in 2002, set out to address Israel's chronic water deficits. The desalination plan was updated on July 2007 to increase the capacity of new sea water desalination plants to the amount of 505 MCM/year by the year 2013. The production of desalinated water will be divided among five main plants along the Mediterranean coast. This constitutes a 35% expansion of natural water sources.

Desalination constitutes the most recently adopted technological component of Israel's water management strategy. In the past, prohibitively high costs limited the scope of desalination to reverse osmosis facilities in remote southern agricultural communities and at the Red Sea resort town of Eilat. New membrane technologies and the reduced energy and economies of scale associated with mass production allow very high quality drinking water to be produced on at a cost of $0.52/m3. The lower cost of desalinated water now makes it economically viable for both commercial and domestic use.

The first of the desalination facilities to go into operation in 2005 is the Ashkelon plant, on the southern tip of Israel's Mediterranean coastline, located adjacent to the local electric power station. The Build-Operate-Transfer (BOT) facility guarantees a production capacity of 100 MCM/year (about 5% of Israel's water supply). The project relies on Sea Water Reverse Osmosis (SWRO) technology, which continues to offer the most technologically and economically feasible treatment. In fact, it is the largest and most advanced SWRO desalination plant in operation in the world to date and also the first desalination project ever to beat a target price of $0.52/m3. Surprisingly, recent increases in oil prices have had little effect on production costs.

While concerns for the concentrated discharge of brine into the sea have been voiced, energy remains the greatest environmental challenge for the desalination process. The Ashkelon facility utilizes natural gas and is extremely energy efficient. The provision of a dedicated power plant is a major factor in both safeguarding operational reliability and reducing energy costs, as it is offers protection from daily or seasonal demand fluctuations.

The high quality of the water produced by the desalination plant offers new opportunities for desert agriculture. The new plant incorporates a treatment process to address the natural boron concentration in seawater; with a removal efficiency of 92%, the process reduces boron concentrations down to a mere 0.4 mg/l. This solves a vexing problem faced by Israeli farmers who reuse treated wastewater that contains high levels of boron.

The desalinated seawater's hardness levels are relatively low and the desalinated water is actually mixed into the national water grid. When the city of Beersheva began using the desalinated water in winter 2006, chlorides in the treated wastewater it sent to the farms in the surrounding desert plummeted to 100-150 mg/l, concentrations that even critics of widespread sewage reuse find sustainable.

Subsequent plants are in different stages of planning and implementation. The two desalination facilities planned inland that will treat large local supplies of brackish groundwater, containing lower salt concentrations, are expected to make high quality, potable water at roughly $0.35/m3.

2.4.3 Treated Wastewater – The Dan Reclamation Project

Israel is a world leader in wastewater treatment and reuse, applying innovative secondary, tertiary and even quaternary purification methods that recycle effluent to meet a variety of demands. However, older plants need to be expanded and upgraded to allow meeting new stringent effluent quality requirements expected for industrial and agricultural reuse.

The Dan Reclamation Project is an excellent example of utilizing the entire water chain vital in a region with scarce natural water resources by investing in reclamation technologies that sustain multiple layers of the water sector. The project was created to deal with increasing quantities of effluent in the Dan Region, comprising the greater metropolitan Tel Aviv coastal area, with a population of over 2 million residents. At the same time the intent was to increase water supplies in the southern arid areas of the Negev region to be used to prevent land erosion and sustain agriculture. This enables drinking quality water originally allocated for agriculture to be exchanged for municipal use.

Wastewater from the Dan Region is treated at the advanced Dan Region Waste Water Treatment Plant (WWTP), built with government funds. After treatment the high quality effluent from the WWTP is applied to six infiltration fields, which permeates into the coastal aquifer, for further treatment by means of Soil Aquifer Treatment (SAT).

2.4.4 Soil Aquifer Treatment (SAT) for Sustainable Agriculture

Reclaimed water for irrigation of food crops requires a high level of purification. For that purpose a unique technology was developed locally – Soil Aquifer Treatment (SAT) – and applied at the Dan Region waste treatment facility.

Effluents from the Dan Region plant are delivered to infiltration fields in the sands, where they are recharged into the aquifer by alternate regimes of flooding and drying. As the water seeps through the ground, it undergoes physical, biological and chemical processes that significantly improve the water quality. The long retention time in the aquifer provides for a very high quality effluent, which is then pumped out by a series of production wells that surround the recharge area. The underground stay in the Coastal Aquifer also serves as a seasonal and multi-annual storage for large quantities of water during periods of low consumption.

The very high quality of the treated wastewater is suitable for all agricultural crops with no restrictions or risk to public health (pathogen free). This reclaimed water is then transferred via the "Third Line" to farmers, for unlimited agriculture use (at a special tariff), via a system that includes production wells, transmission lines, pumping stations, water disinfection plants, and a series of reservoirs. During 2004, the plant treated 122 MCM of wastewater annually, and with the backup of the coastal aquifer, returned 140 MCM of reclaimed water to the Negev.

The solution is a sustainable system that treats marginal water of the central coastal region and supplies the treated effluent for unrestricted agricultural irrigation in the southern arid areas. In the future, as land becomes scarcer, the SAT will be complemented with other treatment technologies for tertiary wastewater treatment such as membrane filtration (UF, nano and RO technologies).

2.5 Water Demand and Pressure on Resources

The three main economic sectors: agriculture (58%), domestic (36%) and industry (6%) consume most of Israel's renewable water supply.

Table 2.2: Water demand by sectors 2004 (MCM/year, Source: Water Authority, 2005)

Sector	Total (MCM/year)	Fresh (MCM/year)	Saline (MCM/year)	Marginal (MCM/year)
Irrigation	1,129	565	185	379
Industrial	113	82	30	2
Urban	712	705	3	3
Domestic Total	1,954	1,352	218	384
International treaties	100	100		
Total (MCM/year)	2,054	1,452	218	384

In the agricultural sector, the share of high quality fresh water has diminished relative to the total supply and stands at about 50%. The share of recycled and other marginal sources of lower quality water has grown.

Israel's water demand projects a gradual significant increase in domestic water consumption, due to natural population growth, immigration, and an increase in the standard of living. An effective means in alleviating water demand pressure is promoting domestic water conservation, by the use of water-saving plumbing devices in homes and by educational campaigns.

In January 2007, the Water Authority implemented a unique plan to solicit private firms to create water-saving campaigns directed at domestic users. The goal is to reduce the annual domestic water consumption per capita in each of the zones under their jurisdiction. The firms that won the public tenders attempt to create an impact on a day-by-day use patterns and to motivate consumers to install water-saving devices at home. Specifically, the programs include: public awareness campaigns, educational programs for schools and community, dissemination of water-saving-devices for household faucets and water mains at the entrance to apartments and buildings, encouraging the public to fix leaks, switching to water-saving dual-flush toilets and implementing water-saving landscape design into private gardens. The private sector's profit – and the possibility to extend their concession – is a percentage of their success as measured by the yearly water use statistics.

As water consumption per capita is expected to rise, a significant saving in the domestic sector has the potential in delaying costly investment in desalination plants. For example, a 5% decrease in domestic water use is roughly comparable to the Palmachim desalination plant with a production capacity of 30 MCM/yr.

2.6 Degradations and Threats Affecting Water Resources

While quality standards for water have become more stringent in recent years to assure public health, water resources and facilities have often failed to meet these levels, while additional risks and threats to the water resources, facilities, ecosystems and population have appeared:

- **Interface with the hydrological balance**: seawater intrusion to the coastal aquifer as a result of lowered water tables; interference with the hydrological balance and saline water intrusion; lowering of the Kinneret water level due to drought and saline water intrusion; entrance of pollutants to the Kinneret as a result of interference with the ecological balance.
- **Environmental Risks:** urban sewage; agricultural pollutants; industrial, oil and transportation pollutants
- **Operational Risks:** pollution at wells; failure in supply systems and facilities; residuals from water treatment materials; degradation of pipelines; pollution in supply systems; pollution of natural resources as a result of irrigation using recycled water.
- **Trans-boundary & Natural Risks**: Intentional or unintentional, man-made or natural disasters.

Preventing pollution and other risk factors at their source is likely to be the most cost-effective mechanism in the management of water resources.

2.6.1 Rehabilitation of Polluted Wells

Between 1997 and 2005, some 152 drinking water wells were banned for water production, due to high Nitrate levels. Most of the wells are located in the Dan region over the Coastal Aquifer. The Hydrological Service and the Demand Management Unit at the Water Authority, created a grant program to rehabilitate those wells. Applicants need to demonstrate a concrete plan to dispose of pollutants as well as the technology to achieve it.

Since the program began about 42 proposals were examined (representing a total production potential of 44 MCM/yr), 11 were completed and are operating. The program exempts the contractor from the extraction levy for 10 years, once the water is designated to be fit for drinking. In addition, the contractor received a one-time grant of $0.35 for nitrate removal and $0.24 for micro-pollutants removal from each cubic meter that was approved for production.

Newer and more advanced technologies for removing these pollutants should return a higher percentage of these to service. This case is an example where the technological advantage and the long experience of Israel in water management can be put to the benefit of regional neighboring entities and to the international community by sharing knowledge and water technology projects.

2.7 Treatment of Wastewater – Improved Standards

The proportion of wastewater produced that has been subjected both to collection and has been adequately treated was 94% in 2005 whereas the level in 1980 level was 59%. The potential of wastewater recycling is the volume of sewage produced, its share in the water demand and the percentage of sewage collected, treated and reused.

Since recycled sewage water is now a customary water source for non-drinking purposes, Israel has made progress by establishing and approving new standards for upgrading the treatment level of sewage water. The use of recycled water on agricultural fields is conditioned, among other things, by an approval from the Ministry of Health and the Hydrological Service of the Israeli Water Authority in order to avoid irrigation along sensitive hydrological spots that may affect sources of drinking water.

The Water Authority has decided to upgrade the quality standards for irrigation with treated wastewater and make them more stringent. The intent is to make the disposal of and irrigation with reclaimed wastewater a sustainable process. This involves safeguarding the appropriate sanitation and health standards while preventing damage to agricultural land, nature, streams and underground aquifers. The Authority will be investing ¼ billion dollars to upgrade sewage treatment facilities by the year 2015.

3. Major Constraints and Challenges

The main challenges of water management in Israel are: building enough desalination plants on time, promoting urban water conservation, improving sewage treatment while preventing inadequate disposal, improving reuse of recycled water, educating the public to conserve water, maintaining landscape values of river corridors.

The main constraints for sustainable development in the water sector are: limited supplies; intensive use; competing users; and inability to supply water to future generations at present prices. In addition, the fact that water spans multiple economic, societal, governmental, and environmental issues dictates the need for advanced multi-disciplinary tools and innovative approaches and technologies that characterize Israel.

Among the challenges that Israel would have to surpass to reach the above objectives are:

- Preventing natural water source contamination and treating polluted sources
- Creating multi-layer monitoring systems at all scales from catchment to water basins
- Ensuring secure and safe drinking water
- Upgrading sewage treatment
- Defining R&D goals for the water sector and allocating funding for basic and applied research.
- Enlarging water supply (by desalination and use of other marginal sources) and lowering its production cost
- Adjusting and managing water prices in all sectors to reflect cost and scarcity
- Implementing responsibilities of the National Water and Sewage Authority
- Increasing clarity regarding the authority of each governmental stakeholder
- Upgrading infrastructure in peripheral areas
- Improving communication between stakeholders regarding regular scheduled activities and threats
- Creating useful indicators for policy makers for evaluating progress
- Improving residential water conservation
- Setting standards and ordinances to regulate ‘Mekorot’, water consortiums and private entrepreneurs
- Improving water security issues