ISRAEL

ABSTRACT

Israel achievements in water resources development, agricultural production and irrigation technology are matched by the magnitude of the still facing problems of quantity, quality and cost of water for irrigation. Major constraints among others include: increased water scarcity; depleting resources, frequent droughts; degradation of water quality; technological uncertainty and high cost of non-conventional sources; rapid urbanization, abandonment and desertification of agricultural land. However, to maintain the Israeli agriculture's unique and remarkable achievements, under a dynamic and changing world, new policies related to future needs for water, food security and agricultural production are being crystallized, aiming to make the agricultural industry freely competing with industrial and domestic users. Emphasis is on integrated water management of conventional and non-conventional sources, increased water use efficiency, coupled with advanced agricultural production. Furthermore, assuming that the peace process would create a strong regional commitment to avert water crisis, regional cooperation in agricultural production, water resources development, water transfer and interconnection of water systems can be envisaged.

1. INTRODUCTION

Israel on a land area of 20,770 km2 is divisible into three longitudinal strips running from north to south. The average annual rainfall varies from 600 - 700 mm in the north to 30 mm at the south. Israel's population is 6.0 million, of which 90% lives in urban areas and 10% in rural areas. The number of farming households is 25,000. Farm employment contributes 3.1 per cent, of the total employment or approximately 67,000 persons. Out of the total area, arable land amounts to

652,000 ha. The area actually irrigated is 230,000 ha or approximately 35 per cent of the arable land. The land holding allotted to a farming unit in the collective and cooperative settlements vary in size according to the soil and climatic conditions. The average holding is 7 ha.

The prevailing arid and semi arid conditions of Israel make irrigation imperative for the development of intensive agriculture and food production. Available renewable potential is already fully utilized, while the widening gap between supply and demand is made up with marginal resources, especially, reclaimed municipal wastewater which is becoming an increasingly important source of water for agricultural and industrial purposes. Cloud seeding is practiced, adding 10 - 15% of rainfall, and desalination of brackish and sea water is fast expanding. Water scarcity is further compounded by rapid degradation of water quality. Due to global warming and frequent droughts, the regime of the natural replenishment is decreasing while influxes of pollutants, due to man made activity above the aquifers, are increasing, resulting in the increase in mineral and other pollutants contents in groundwater.

Agriculture which dominated the national economy in the early years has gradually decreased as reflected by the sector contribution to the national product. Fierce competition with other markets and reduced government involvement in terms of protective quotas, direct support and subsidies were the major factors contributing to the fall. As the result, far reaching economic and organizational adjustments were made within the sector, encompassing: production, economic framework and organizational structure. Structural changes included rapid industrialization of the farm settlement and reduced degree of cooperation within the farming communities, at the local and regional levels. Changes were also made in the family production units, the supporting cooperative organizations and especially the change of focus from direct production to agro-industry and services.

The above process, constraints and anticipated initiatives and development to achieve sustainability by the year 2025 are discussed, highlighting concerns about the sector vulnerability, development plans and sector vision for the future.

2. AGRICULTURE SECTOR POLICY ISSUES

Agricultural production and Crop Diversification : Currently, irrigated agriculture still consumes more than 60% of available water resources, while contributing only 2 % of the GDP. Agriculture has therefore reached a turning point in which the highly capable industry have to be diverted from conventional production into advanced production systems, capable of competing with industrial and economic users on available water resources. A competitive market orientation is essential for the transformation in production and cropping systems.

New production systems are being envisaged, having the capability to :

- compete with other economic sectors on available water resources
- produce high value crops, innovative highly productive and less demanding in water
- favorably competing with import from external markets.

Other aspect being considered is:

- the transition of agricultural production from the temperate coastal plain to the arid south and the related effects on production and the desert ecology

Agriculture and the Environment : Agricultural production is considered to be compatible with the environmental protection and issues of open space, soil conservation and protection of the natural vegetation and water resources can greatly benefit from appropriate agricultural production systems. Accordingly, sustainable use of brackish and effluents without detrimental effects on the environment, water conservation and extremely efficient use of water in agriculture alleviating environmental pollution are attempted. Short, medium and long term targets are being evolved, as related to the following :

- efficient production to avoid agricultural waste;
- reduced use of fertilizer and pesticides;
- recycling of wastewater, sludge and compost;
- use of brackish and wastewater for irrigation
- rational use of land and water resources, and
- production of functional food.

Water Management : To cope with the combined process of water, agricultural production and environment, a restructuring of water management is being conducted, aiming to reduce the heavy reliance on costly non-conventional resources and the need to rationalize the use and conservation of natural resources in general and in agriculture in particular. Water as an economic good and a greater public participation and involvement in planning implementation and operation stages of development related to agriculture and environment is being achieved. Functions previously performed by the government are being transferred to the private sector, using free trade and economic principles, although environmental, social (ability to pay) and food security aspects are not overlooked.

Guiding principles include :

- economic value of water and water as an economic good is considered,
- charging the full cost of water is attempted,
- greater public participation in the planning, implementation and operation stages of water systems is pursued,
- the private sector is encouraged to fulfill functions previously performed by the government
- environmental, social (ability to pay) and food security aspects are considered.

3. WATER RESOURCES

Available Resources : The average annual renewable potential amount to some 1,600 MCM, of which about 95% are already exploited and used for domestic consumption and irrigation. About 80% of the water potential lies in the northern parts, hence, large quantities of water have to be conveyed over 200 km to supply the water needs. Surface water contributes about 33% and groundwater supply the difference, mainly from two major aquifers. Artificial recharge is practiced through spreading basins and single and dual purpose deep wells connected to the National Water Carrier. Currently, about 275 MCM of effluents, treated to varying degrees, are already utilized for irrigation, about 65% of the generated wastewater. Cloud seeding has been practiced for last 30 years, yielding a significant increase of 10 - 15% in rainfall. Several small and medium desalination plants have been installed, for desalination of brackish and sea water for domestic water supply, including a 10,000 cum/day sea water desalination plant in Eilat. Available water resources and water budget figures, for the years 1997 - 2020 are given in Table 1.

Table 1. Water Supply and Demand – Israel 1997-2020 (MCM/year)

Water Supply							
Year	Population (Million)	Water Sources					
		Surface Water	Ground water	Brackish Water	Treated Effluents	Desali-nated	Total
1997	5.8	600	1020	125	275	10	2030
2010	7.4	645	1050	165	470	100	2430
2020	8.6	660	1075	180	565	200	2680

Water Demand						
Year	Urban	Agricultural Irrigation				Total
	Sector	Fresh	Brackish	Effluents	Total	
1997	772	880	103	275	1258	1960
2005	980	750	95	380	1250	2220
2010	1060	680	85	495	1260	2430
2020	1330	600	60	565	1350	2680

Source: Israel Water Commission, 1998

Water Allocation : In 1959, a comprehensive water law was passed making water resources a public property and regulating water resources exploitation, allocation and prevention of pollution and water conservation. Under the law all available water resources are under public domain and made available for use by the consumers as directed by the water Commissioner, the sole statutory body responsible for executing the State's water policy, regarding exploitation, allocation and conservation of water. The Water Commissioner issues abstraction license and allocations to consumers.

Water Supply and Demand **:** Annual renewable water resources amount to about 1.7 billion cum, compared to an annual water demand of about 2000 MCM/year, of which about one half is used for agriculture and the remaining is used by the urban and industrial sectors. All the Israeli settlements are served by public waterworks supplying an average of about 250 litres/capita/day. Similarly, about 95% of the return flow is collected and about 80% is adequately treated and in many cases reused for irrigation (42%). Currently, the urban sector consumes about 700 MCM and the annual increase is about 20 MCM per year, about 4%. Israel population is projected to increase to about 8.5 million by the year 2020 and urban water consumption to about 1 billion cum.

Drought Management **:** Water is supplied from all available resources including: groundwater, storm water, treated effluents and desalinated water. To overcome spatial and temporal gaps between supply and demand, most of the country's fresh water resources are inter-connected into the National Water Carrier. The Carrier, the backbone of the national system, conveys an annual amount of about 1,100 MCM over 180 km from north to south. An integrated network of pumping stations, reservoirs, canals and pipelines is used to supply water under pressure for all the domestic, industrial and irrigation consumers. During the winter months, excess supply is used for artificial recharge of the aquifers and establishment of hydraulic barriers. Thus, groundwater abstraction is used to balance between wet and dry years, providing 55 to 70% of the total supply, based on the prevailing climatic and hydrological conditions in a specific year.

Water Quality **:** The quality of supplied water in Israel varies from very low salinity water of the Upper Jordan River (10 mg/l of chlorides), to medium salinity in of the Kineret and major aquifers (100 - 200 mg/l of chlorides) and excessive salinity in the non renewable aquifers in the south (more than 1500 mg/l of chlorides). Due to irrigation, a gradual increase in salinity and other pollutants is observes. Based on past trends, more than 25% of available groundwater will have a chlorides content of more than 250 mg/l by the year 2025.

Water Conservation **:** Best technology and best practices are being applied to protect and minimize the pollution of water resources. Water conservation maps, restricting land use activities above groundwater resources, were produced to protect the underlying resources. A regular monitoring of water resources is being conducted. Natural replenishment and recharge, water table levels, abstraction, salinity (chlorides) and pollution (nitrates) data are continuously recorded and reported. The data provide an effective tool to influence the planning, the development process and permissible emission of pollutants to the environment.

Public water conservation campaigns coupled with technical and economic measures are also being applied to reduce consumption and to increase awareness to water scarcity and water quality conditions.

Financial, Institutional and Management Programs **:** The Government through the relevant ministries provides grants and low interest loans for the improvement and expansion of water supply and wastewater treatment plants.

4. AGRICULTURE

Agricultural Economy **:** Israel's agricultural sector is characterized by an intensive production systems, stemming from the need to overcome the scarcity of natural resources, particularly water and arable land. Despite the continuous decrease in the number of farmers, agriculture still plays a significant role in the national economy, contributing, in 1996, about 1.9 % of the GDP, 7% of exports and 3.1 % of the total work force (66,500). Agriculture is particularly important for the outlying areas where agriculture provides the sole means of livelihood for the population. Israel produces 92% of its own requirements, supplemented by imports of grains, oil seeds, meat, coffee and sugar. Agricultural export amount to US $ 1.42 billion (7% of the total export). In addition, the production of agricultural inputs stands at over $2 billion, of which 70% is exported.

Agricultural Production **:** Agricultural production encompasses citrus, avocado and deciduous tree plantations, field crops of which cotton is the major crop, vegetables and flowers and fish ponds. Most of arable land estimated at about 430,000 ha is cultivated and about 50% is irrigated. The extent of the irrigated area varies and depends on the water resources capacity and agricultural commodities market, within a particular year. Agricultural production figures for 1996 and projections for 2020 are given in Table 2.

From the above figures, the total cultivated area and water available for irrigation will not significantly changed over the planning period, but the water quality will be dramatically reduced, by large substitution of fresh water with treated effluents. Other changes will include :

- transition and shifting of agriculture production to the arid south
- substitution of fresh water for brackish and wastewater effluents for irrigation
- adaptation to open markets and free competitive trade, requiring further R&D to strengthen the Israeli advantages and identify new ones.

- development of water and salinity tolerant crops and further diversification
- environmental protection/recycling of agricultural waste

Table 2. Cultivated Area, Major Crops and Irrigation Water Use, 1996 and 2020

Major Crops	Cultivated Area (ha 000)		Irrigation Water Use MCM/Year					
			Fresh Water		Marginal Sources		Total	
	1996	2020	1996	2020	1996	2020	1996	2020
Tree Plantation	84	82	490		70		560	
Field Crops	233	240	185		205		380	
Vegetables & flowers	43	55	175		25		190	
Fish Ponds	3	3	30		70		100	
Fallow	68	70						
TOTAL	428	430	880	600	378	750	1265	1350
Of which: Irrigated land	183	200						
Dry Land & Fallow	245	230						

Source : Compiled from Central Planning Authority, Ministry of Agriculture, 1998.

Crop Diversification : Market forces at home and abroad, and a scarcity of land, labour and water are forcing major changes. Increasingly, there is a shift from extensively farmed mass produced crops to intensive growing of products, like hybrid tomatoes or genetically engineered banana tree saplings. Moreover, to enable the growth of crops under a wide range of climatic conditions, advanced growing methods are used including greenhouses with climatic control systems, soilless culture and biological pest control.

Israeli science has already acquired the basic capability in genetic engineering and biotechnology, essential to support large scale production of innovative products, such as :

- large scale production of hybrid seeds and other propagation material,
- production of medicinal plants for the extraction of natural plant extracts for use in medicine and food industries.
- production of engineered organisms for crop protection, substituting expensive and environmentally harmful chemical pesticides
- conversion of conventional and low income agricultural production systems into agro-industrial systems, producing high value plant extracts and other sophisticated products of high commercial value.
- utilization of reclaimed wastewater for the irrigation of patented hybrid seeds.

To achieve the necessary transformation in agricultural production, the existing R&D infrastructure has also to change to support large scale production of patented and protected propagation material and other high value added products. The necessary R&D related to environmentally friendly applications in agriculture has also to be developed.

Aqua-culture **:** Intensive form of aquaculture, using saline and sea water are extensively used in man-made ponds and reservoirs and off-shore floating cages. Advanced water purification techniques, oxygen diffusion and protein rich food are used to increase production rate from 0.5 kg per cum to 20 kg and more in a controlled system.

5. BIODIVERSITY

Natural Vegetation **:** Israel is known for its richness in natural vegetation and diversified species of Mediterranean, Irano-Turanian and saharo-Arabian origin, where domestication of Old World crops began. Beyond the intrinsic value, the diversified plant population has been an extremely valuable genetic source for improvement of agricultural crops and extraction of specific drugs. The active ingredients in more than 25% of medical prescriptions derive from natural plants, while the demand for genes and chemicals that remained untapped within the world remaining wild life is fast growing.

Extinction of Species **:** Despite the overwhelming demand for new genes and chemicals, biodiversity is affected by human activities, leading to unintended reductions in diversity of the live organisms. Although the conversion of land into areas of intensive agriculture and urbanization is absolutely inevitable and in many ways compatible with the functioning of ecosystems, the current extinction of species is exceeding the current rate of speciation. In Israel, because of the rapid increase in population and urbanization, the fragmenting landscapes and ecosystems for intensive agriculture, rapid urbanization, transport development(railway, roads, such as the Trans-Israel Highway, etc.) or of drying up or wetting wetlands for tourism, the genetic resources of native species are under a serious threat of extinction.

Israeli Gene Bank (IGB) : To avoid the disappearance and the extinction of endangered species and on the other hand to beneficially exploit the natural endowment, IGB was established having the responsibility for: development of in-situ conservation techniques; formation of gene banks; search for plants potentially suitable for extraction of beneficial substances; and, promote regional and international cooperation in preservation of species and biological diversity. A strategy is being pursued with an overview of genetic conservation, conceptualizing measures and implementation plans which will contribute to gene resource conservation, including :

- identification of target species for conservation
- identification of immediate and future threats to the gene pool of target species.

6. IRRIGATION

Irrigation Water Use **:** The agricultural sector consumes about 1200 MCM/year to irrigate about 200,000 ha. Irrigation water comprises of fresh and marginal water. This quantity has not changed significantly over the last 20 years, despite the significant increase in agricultural production. In future, the total consumption will not be reduced, although the quality of supply will be drastically reduced.

Irrigation Water control **:** Computers were introduced to allow real-time operation of the irrigation systems, providing precision, reliability and savings in manpower. Recently, satellite linked valve control was implemented to control distant water systems. Soil and plant moisture sensors are also used to provide information on moisture, allowing automatic operation of the system when needed.

Irrigation Efficiency **:** The wide scale adoption of low volume irrigation systems (e.g., drip, micro-sprinklers) and automation has increased the average efficiency to 90% as compared to 64% for furrow irrigation. Other factors include :

- water metering
- water pricing policy,
- computerization and remote control of irrigation

- fertigation - fertilizer application via the irrigation systems

As a result, the average requirement of water per unit of land area has decreased form 8,700 m3/ha in 1975 to 5,500 m3/ha in 1995. At the same time agricultural output has increased twelve fold, while total water consumption by the sector has remained almost constant. Further irrigation efficiency is being attempted by regulating water application to each individual plant, using individual moisture sensing emitters. The root volume can be controlled, leading to a shortening of the crop growing cycle. Also, it is assumed that plant metabolism can be manipulated changing crop leaves radiative characteristics, to reduce the transpiration rate per unit of yield and biomass.

Pricing of water for irrigation **:** The average water cost indicated by the National Water Co. - Mekorot. is US C 31/cum. water charges for the various consumers are fixed by a parliamentary committee. Recently, an Increasing Block Rate Prices system is applied, leading to 10 - 15% savings in water used for irrigation, as shown in Table 3.

Table 3. Block Rate Tariffs for irrigation water supply - Mekorot, 1996

Water Source	Part of Allocation (%)	Price (US C/cum)
Fresh Water	1 - 50	15
	50 - 80	18
	80 - 100	21
	Average	19
Tertiary Effluents	Low Season	14
	High Season	15
Secondary Effluents	Average Price	12

Source : Israel Water Commission, 1996

Government Subsidy **:** Currently Government support amounts to bout 20% of the cost, although a substantial increase in water charges coupled with a restructuring of the National Water Company - Mekorot has resulted in a significant reduction in Government subsidy from 50% in 1992 to about 20% in 1996.

7. ENVIRONMENTAL ASPECTS

Sustainable Agriculture : Environmentally Friendly agriculture rationalizes agricultural activities in an attempt to alleviate environmental pollution and to minimize waste generation and maximize reuse of wastes. Measures adopted for short, medium and long term include :

- controlled plant nutrition and released/leaching of nutrients and pesticides, under irrigation and composting
- development of alternative soil phyto-sanitation techniques
- maximum recycling of wastewater, sludge and compost, and,
- reduction of salinity constituents and potentially toxic trace elements in sewage effluents
- understanding the long term effects of irrigation with effluents, and
- rational use of land and water resources

8. INSTITUTIONAL REFORM

Sector Deregulation **:** The Israeli water economy is on the verge of a major reform in which seeing water as a cheaply available public resource is to be abandoned and a new policy reflecting water's limited supply and competitive economic value is to be fully considered. The general view is that market forces and sector deregulation are the most suitable tool for the efficient use in the agricultural sector. Accordingly, the role of the National Water Company - Mekorot is to be limited to the operation of the main grid - National Carrier, while new private regional water supply schemes will be created and defined as public service under the supervision of the Water Commissioner.

Water Tariff **:** Water tariffs that were largely determined by the government, based on the existing block rate and the non-tradable allocation are to be changed into a market negotiating systems. Israel has already embarked on the political process of positioning agriculture in the proper place vis-a-vis national water allocation and use policies which were fully debated by a public hearing committee. To balance between supply and demand, a shadow price reflecting the water value at source will be added to water charge, thus rendering the historic allocations into a non - effective issue, but maintaining their regulation order in case of emergency or under a series of drought years. The price of water will include not only the direct costs but also its scarcity value, quality deterioration, over exploitation (mining) on one hand, and the social aspects, such as access to water and the ability to pay of low income groups, on the other. Subsidised prices if available will be fully indicated and calculated reflecting their portion of the full costs and budgeted for each specific system.

Water Trading : Shares allocation attracting dividends and voting rights will replace existing water rights. The shareholders will control the performance of the new regional corporations, while external efficiency will be achieved by the market forces and the value of the shares in the financial market.

9. DISCUSSION

Strategic issues, describing water industry and agricultural production situation, and possible solutions to achieve sustainable water world and best practices were discussed, covering constraints and anticipated initiatives and development to achieve sustainability towards 2025, including possible commitments to avert water crisis. An unprecedented water crisis could however increase the scarcity and quality degradation of renewable and accessible water resources, while water related disasters and diseases could trigger a chain of consequences, leading to reduced consumer confidence in public water supply systems, decline in food production and massive desertification. Therefore, for a sustainable situation, further technological improvements are necessary, to increase efficiency and positive impacts of integrated water management, across sub-sectors and uses, increasing allocation efficiency and preventing local conflicts.

For best use of local advantages, under dynamic and changing world, Israel is already in the process of crystallizing development policy to support decision making with regards to future needs in water and agriculture. The science-based technologies which have brought about so far, the dramatic increases in the quantity and quality of the country's agricultural produce, through a two-way flow of information between research personnel and farmers will be further exploited to support the necessary transformation of the sector to a sustainable world. A continuing growth in agricultural production, using the same amount of land and water, and less, is anticipated due to the close co-operation between researchers, extension workers, farmers and agro-industries, in which government agencies, academic institutions and co-operative bodies work together on a challenging economic and a social goal.

Improved production systems, highly productive, less demanding in land and water, adequately competing with other industrial and economic users will be developed. The hi-tech agriculture, incorporating new cultivation techniques and new crops, adjusted to irrigation with brackish and secondary effluents will be expanded. Further improvement of water use efficiency (improved distribution systems and ultra low volume irrigation) and techniques suitable for irrigation with marginal resources and soil amelioration will be applied, contributing to sustainable land use and conservation of agricultural land. Similarly, various innovations are expected to influence the water balance including: induced rainfall, improved forecasting techniques of rainfall and water balance, elucidation of the global warming and its effects on water resources and economic competitive desalination systems.

It is also assumed that a strong commitment to avert water crisis will emerge, seeing water as an economic good dealt with financial and economic terms. An economic approach will induce the reallocation of water resources, leading to efficient production and allocation systems, suitable to irrigation under water scarcity conditions. Sustainable use of good and poor quality water, conservation of rivers, water courses and aquifers will be achieved, while still considering social, cultural and environmental goals.

On a regional scale, by all standards Israeli agriculture is very small and bears no competition to the regional agriculture. Most of the innovations are transferred to the world at large as agricultural produce, production inputs and know-how. For many years, Israel has also been sharing its expertise with the developing world and most of its accumulated experience in agriculture, irrigation technology and water management was found to be easily adaptable to the needs of developing countries.

Cooperation within the region has already commenced and water issues form part of the peace treaties with the Kingdom of Jordan and the Palestinian Authority. Agricultural enterprises and joint ventures are already well established in several countries, within the region, taking advantage of the Israeli technology and the land, water and manpower availability and other economic incentives in neighboring countries. Based on on-going cooperation, a set of local and regional targets, related to water resources development, regional water transfer and interconnection of water systems, can be reached.