Water use efficiency and economic approach

National study Egypt

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CONTENTS

Summary

Integrated water resources and demand management has been selected as the first priority field of the Mediterranean Strategy for Sustainable Development (MSSD) adopted in 2005 by all the rim countries and the European Community. Enhancement of water demand management policies to stabilize water demand by 2025 is a major objective. Reduction of water losses and wasteful use of water and increasing the added value per cubic meter of water used, are the main factors to improve efficiencies. Furthermore, economic instruments are main tools for guiding policies towards Water Demand Management (WDM) to achieve cost recovery without sacrificing social equity. The Blue Plan's scenario for water savings by 2025 comprises: (i) For drinking water in municipalities: reduce losses rates stemming from distribution to 15% and leakages from users to 10%; (ii) For irrigation: reduce losses rates stemming from transport and distribution to 10% and raise irrigation efficiency by plot to 80% ; and (iii) For industry: extend recycling to 50%.

This report presents inputs and contribution from the country of Egypt towards the above mentioned efforts. It comprises an attempt to assess the efficiency of water use at the national scale for three main subsectors of the water sector, namely: the agricultural sector, the municipal sector, and the industrial sector. Best estimates for the water efficiency index, based on collected data and existing national water-related strategies, are calculated. National water saving potential and efficiency improvement objectives are evaluated along with projected expenses and corresponding savings.

The agricultural sector contributes to about 14% of the national Gross Domestic Product (GDP) and employs about 30% of the labor force. The industrial sector provides about 34% of the GDP through employment of 17% of active labor. The service sector (including tourism, communication, transport, construction) comprises the rest. The water demands are near 80 Billion Cubic Meter/Year (BCM/y) while the Nile supplies a constant renewable annual share of 55.5 BCM/y. In the practical absence of rain, about 6 BCM/y of fossil groundwater is being extracted. The rest of the demands are satisfied through intensive water recycling in the form of reused treated wastewater, recycled mixed agricultural drainage water, and recycling of excess irrigation water recharging the Nile alluvium aquifer. Furthermore, newly reclaimed arable lands, in desert areas, constitute slightly more than one quarter of the 8.5 million feddans of cultivated land. Nevertheless the total cropped area is nearly 14 million feddans with an average crop intensification factor of about 1.7 since the Delta old lands usually produce 2 – 3 crops annually.

In the agriculture sector, the average conveyance efficiency for Egypt is about 75% and the corresponding application (plot) efficiency is 65%. The drinking water efficiency is on the average equal to 74% reflecting both physical (conveyance) and economical (billing) efficiencies. Specific case studies indicate a slow, yet steady trend of improvement over the past six years associated with massive investments and transformation of the sector from being governmental to a more autonomous economic entity. Data concerning recycling within the industrial sector is scarcer than data on the available water resources! Nevertheless, field surveying of selected industrial enterprises provides a basis for an estimated recycling efficiency of 5.5%.

National targets aim at achieving 85% drinking water efficiency by 2030. Targets for industrial water use are more concerned with enhancing the quality of effluents.

Considering the specific, and to some extent, unique features of the agricultural sector, a big dilemma occurs regarding whether the irrigation efficiencies, in their currently presented forms, are indicative of the real situation or not. With heavy reliance on recycling, assumed water savings corresponding to enhanced efficiencies creates a state of virtual reality. In a closed system environment, like the Egyptian case for old lands, the so-called losses pertaining to seepage, groundwater recharge, or leaching to drains are actually, at least from a mass balance point of view, beneficial losses. The only true losses in water quantity are attributed to evaporation, while true losses in the effectiveness of the resource are attributed to deterioration of water quality after each cycle of reuse.

While the irrigation efficiency enhancement program proposed by the Egyptian ministry of agriculture provides a prosperous future, it is unfortunately too good to be true. Basic assumptions of achieving 13 Million Cubic Meter/Year (MCM/yr) of water savings due to enhanced conveyance and field efficiencies

is far from reality for the reasons discussed before, not to mention the expected social tensions and restlessness at the old lands. A maximum saving of 3 BCM/y seems more realistic, and requires tedious interventions and firm policies. Should that be the case, policy makers are advised to consider the creation of the same water savings (3 BCM/y), at less than 15% of proposed expenditures, through initiation of a program for wastewater treatment (already planned and designed, and awaiting funding). Additional benefits would be to ameliorate portion of the excessive pollution pressure exerted on land and water resources.

Introduction

Egypt is located at the south eastern corner of the Mediterranean and enjoins an area of one million square kilometers. Egypt measures 1262 km from west to east (Mediterranean coast), and 1073 km between latitudes 22° and 32° N. This latitudinal location means that most of the country falls within Africa's dry desert region, except for a narrow strip along the northern coast which experiences a Mediterranean type of climate, (Figure 1). Egypt is practically rainless; its agriculture depends mainly on irrigation. The mean annual rainfall of 18 mm ranges from 0 in the desert to 150 mm per year along the Mediterranean coastal region. During summer, temperatures are extremely high, reaching 38°C to 43°C with extremes of 47°C in the southern and western deserts (mean daily maxima). The Mediterranean coast has cooler conditions with 32°C as mean daily maximum (FAO, 2005).

Egyptian population has almost doubled during the last thirty years, recording a 38 million increment in inhabitants, from 42 millions in 1990 to almost 80 millions in 2010. Inhibited areas in Egypt are about 6% of its total coverage, mainly concentrated in the Nile Delta and around the Nile Valley along with scattered development zones along the Mediterranean and Red sea coasts, the Sinai Peninsula, and few oases in the Western Desert. The former reflects the sever aridity prevailing across most of the country. Increasing population, increasing population density, limited water resources, and hyper-aridity represent major development constraints in Egypt. Climate-induced changes especially more frequent occurrence of extreme events adds another potential constraint.

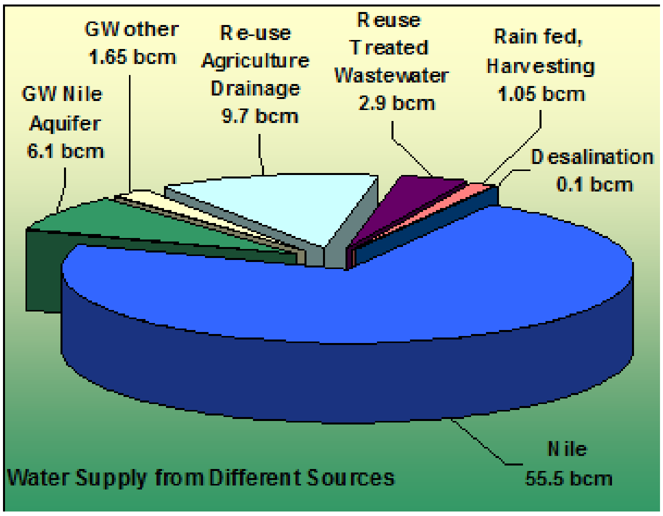
Figure 1 – Map of Egypt

Source: CEDARE, 2011

Historically, the first Paliolithic man in Egypt has been centered around natural springs and depressions which have been effective in collecting rain water during the great pluvial period extending between 120,000 and 20,000 years ago. Hunting has been predominant across the country which was green at this point of history. About twelve thousand years ago, the climate started changing, rainfall ceased, and previously existing green coverage is gradually transformed into harsh desert environments. Several perennial wadies have turned into ephemeral ones while others have completely dried out, filled by air-born depositions, and transformed into paleo-channels. Man and animal are united in looking for more favourable living locations with more water potential, thus several immigration moves has been initiated. Looking for a more sustainable water source, Neolithic Egyptians began to cluster around the banks of the Nile which by then must have converted from a highly variable torrential water way to a more stabilized and prosperous river. This marks the early beginning of the Egyptian Dynasties which established one of the greatest civilizations of the world. For more than seven thousand years Egyptians have been relying on the Nile to provide for their existence, establishing the first ever practiced water management system; flood control, irrigation and drainage, and agricultural development.

1. Freshwater supply

Figure 2 – Sources for water supply

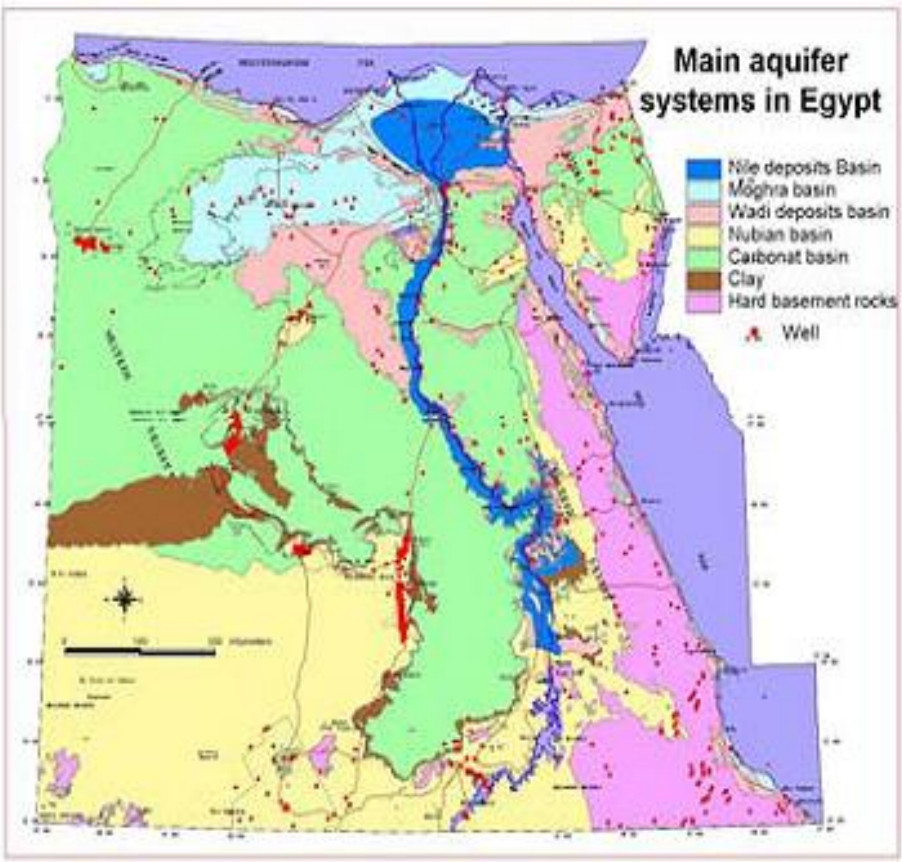


Source: CEDARE, 2011

Currently, the overall average annual rainfall in Egypt is about 18 mm mainly occurring at the northern coast which receives about 150 mm of precipitation per year. In the southern Upper Egypt, Sinai, and along the Red sea coast events of measurable rainfall may be encountered once every 5 to 9 years, sometimes developing into very short, but destructive, flash floods. Precipitation which occurs in winter and late autumn accounts for 1.3 BCM/yr of internal renewable water resources recharging shallow aquifers. The Nile River supplies about 97% of the annual renewable water resources in Egypt. Out of the Nile's average natural flow of 84.0 km^3 /y reaching Aswan, a share of 55.5 BCM/yr is allocated to Egypt according to the Nile Water Agreement (1959). The Agreement also allocates a share of 18.5 BCM/yr to Sudan; while about 10 BCM/yr is lost in evaporation from the high dam reservoir (Lake Nasser), (Figure 2) Wagdy (2009), FAO (2007), NWRP (2007). Thus the total renewable water resources of Egypt are estimated at 56.8 BCM/y. The latter amount of supply is constant and incremental possibilities are not foreseen for the short term. This accounts for an average per capita share of about 800 m^3 /cap/y as of year 2004, while projections forecast a share of about 600 m^3 /cap/y by the year 2025.

Fossil groundwater is hosted in deep aquifers as non-renewable water resources. Also, non-conventional resources include agricultural drainage water reuse, sea water desalination, municipal wastewater reuse, rain harvesting, and brackish water desalination. Fossil water exploitation is estimated at a rate of 1.65 BCM/yr, mainly concentrated at the oases of the Western Desert. The municipal wastewater reuse capacity is currently of the order of 2.9 BCM/yr, while the agricultural drainage reuse is projected to be around 9.7 BCM/yr in the Nile Valley and delta.

Figure 3 – Main aquifers in Egypt

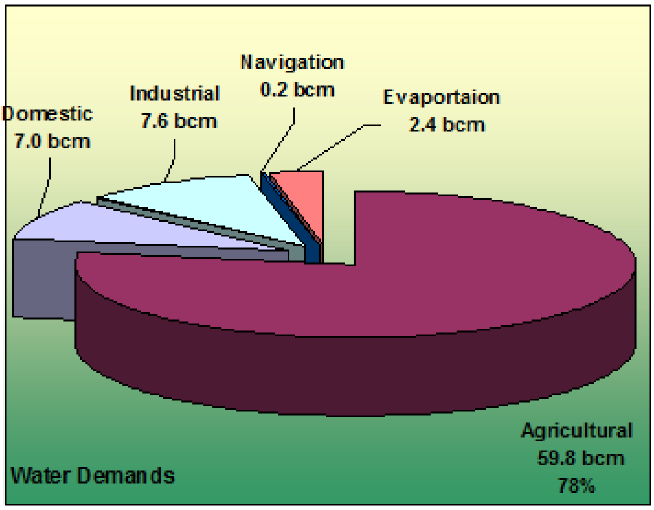


Source: CEDARE, 2011

Groundwater utilization has been steadily increasing in Egypt for the last twenty years. A designated sector for groundwater management has been established at the Ministry of Water Resources and Irrigation to coordinate, develop, and rationalize the national groundwater utilization. There are four major groundwater systems in Egypt (Figure 3), namely; the Nile Aquifer, the Nubian Sandstone Aquifer, the Moghra Aquifer, and the Coastal Aquifer. The Nile aquifer is renewable and underlies the Nile Delta and is characterized by its high productivity and shallow depth of the groundwater table allowing the abstraction of large quantities of water (100-300 m^3/hr) at low pumping cost. Conjunctive use of surface and groundwater is widely practiced by farmers, especially during periods of peak irrigation demands. About 6.1 BCM/yr are annually extracted from the aquifer. Being a shallow aquifer it is extremely vulnerable to pollution by surface induced sources. The aquifer is directly connected to the Nile River system, and thus will be directly affected by programs for reducing conveyance losses in waterways. The Nubian sandstone aquifer is shared by four countries namely; Egypt, Sudan, Chad, and Libya. The whole aquifer contains about 150,000 BCM of fossil water at depths reaching 2000 m. Pumping costs and economies of scale control the development of groundwater from the Nubian Aquifer. The Nubian Aquifer extends also beneath the Eastern Desert. Recent studies show that the shallow aquifers at the middle and south of the desert are connected to the deep aquifer, thus providing a good potential for groundwater development. In the Moghra aquifer, the groundwater flow is in general directed towards the Qattara Depression. The aquifer is recharged by rainfall and lateral direct inflow from the Nile aquifer. Due to the sharp increase in abstractions for groundwater-based reclamation projects in the Egyptian Western Desert and industrial and municipal supply, notably in the Western fringes of the Nile Delta, the water quality and sustainability of this resource is at risk. The Coastal aquifers exist near the western northern coast of Egypt and are recharged by rainfall on the western coast. Quantities that can be abstracted are limited due to the presence of saline water underneath the fresh water layers.

2. Water demand

Figure 4 – Sectoral water demands



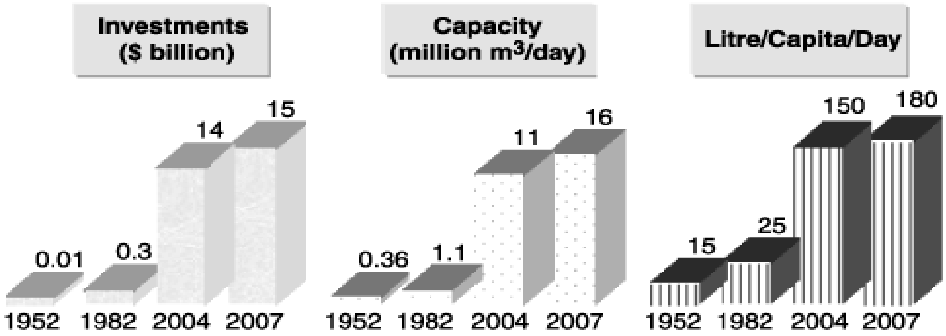
Source: CEDARE, 2011

Various demands for freshwater are exerting excessive pressure on the available water supply. The agricultural sector (including fisheries) is the highest freshwater consumer, utilizing about 78% of the available supplies, while the domestic and industrial sectors consume 9% and 9.9% of the total supplies, NPI (2008). The navigation and energy (i.e. hydropower) sub-sectors are "instream" users; meaning that they utilize the Nile/irrigation distribution system, but they are not net consumers of the water resources. Drainage water spilled to the Mediterranean Sea and the desert fringes of the Nile system contributes the water needed to maintain the ecosystem/habitats of the northern Delta/Lakes. Evaporation losses from the 31,000 Km-long water conveyance networks is estimated at about 2.4 BCM/yr, (Figure 4), Wagdy (2009), IDSC (2007), FAO (2007).

Water resources management, hydraulic control, channel design, distribution networks, and water discharge monitoring has been practiced by Egyptians for over 5000 years. The total dam capacity is currently about 169 km^3 mainly attributed to the reservoir of the Aswan high dam. About 90% of the Nile's hydro-potential has been exploited to generate about 12 Twh. The irrigation potential is estimated as 4.4 million ha. Agricultural drainage through primitive pumping stations and excavation of main drains has been practiced in Egypt as early as 1898. Ditch drainage has been introduced in 1938 followed by sub-surface drainage in 1942. The Egyptian Public Authority of Drainage Projects (EPADP) has launched a comprehensive drainage construction/rehabilitation program in Egypt that covers 8.0 Million feddan of agricultural lands since the late seventies. EPADP accomplished 7.2 Million feddan with surface open drainage till the end of 2004. Parallel with that, EPADP introduced a long-term planning for flexible construction of subsurface drainage in an area of 6.4 million feddan, which widely enabled the use of mechanized pipe-laying, plastic pipes and synthetic envelope materials by public and private contractors. EPADP accomplished 5.4 Million feddan of subsurface drainage till end of 2004.

Drinking water requirements for major urban towns and rural villages have been estimated to be 4.6 BCM in 99/2000 where approximately 97% of urban population and 70% or rural population of Egypt relies on piped water supply. The major cities in Egypt (217 cities) currently enjoy full potable water coverage (100%). Rural access to improved drinking water is now 99%. Sanitation services, however, lag behind water supply, where approximately 72% of urban population is covered by collection and treatment sanitation systems while about 11% of rural population in villages are connected to the sewerage system, thus constituting a pollution hazard to groundwater water resources. Figure 5 traces the progress in sanitation coverage in Egypt. Municipal water is diverted from two sources: surface water which supplies about 83% of total municipal demand and groundwater, which supplies about 17% of total demands. The total municipal demand (drinking water) is calculated to increase by a factor of 1.4 between 2000 and 2017. The total industrial water utilization is expected to increase by a factor of 2.0 throughout the former period.

Figure 5 - National Progress in Sanitation Coverage



Source: CEDARE, 2011

Fisheries rely greatly on water resources and are directly affected by water allocation policies. The total fish production in Egypt reaches 725 thousand tons in the year 2002 where 18% of it came from marine fisheries. A population of about 700,000 fishermen earns their living from inland fisheries and related activities. It is estimated that a minimum of 7.5 BCM/yr of fresh and drainage water is required to sustain the present ecological conditions including fish production from the Delta lakes.

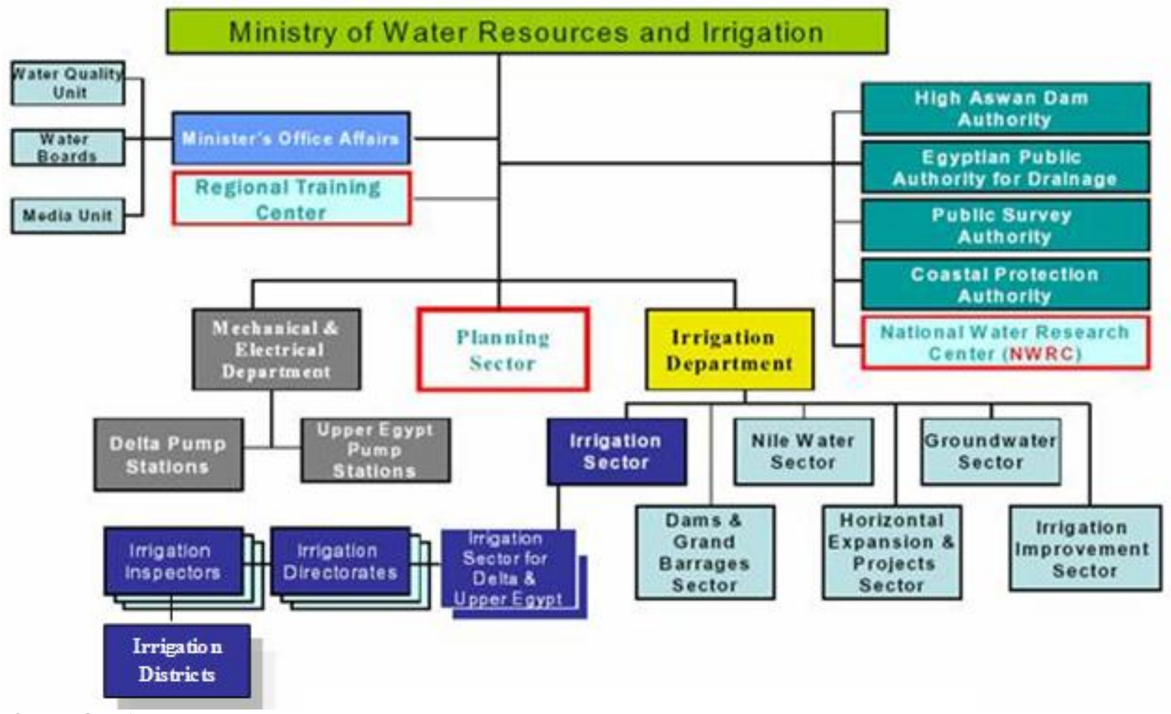
3. Water quality

In general, surface water quality exhibits deterioration as we move downstream with the worst pollution occurring at the northern lakes. The domestic water demands result into more than 4.0 BCM/yr of waste water being discharged into the Nile, out of which 35% are treated. Pathogenic pollution (as expressed by faecal coliforms count) of surface water increased during the 1980s and gradually decreased throughout the 1990s and in all cases it exists in restricted localized areas where improperly treated wastewater used to be discharge to water ways. The government comprehensive plans to extend sanitation coverage and waste water treatment to rural areas are expected to eliminate significant pathogenic pollution by the year 2017. Industrial effluents contribute to about 1.3 BCM/yr of untreated waste water being discharged into surface waters. Food industries contribute to 45% of total effluent discharge and to 67% of the total Biological Oxygen Demand (BOD) load introduced. BOD levels in the Nile, at mid stream, are still below 6 mg/l. The Nile branches experience more Oxygen depletion which may reach a Dissolved Oxygen value of 3 at downstream end presenting potential hazard to aquatic organisms. Industrial effluents contribute to the increased levels of trace elements especially after the construction of the high dam where the potential for flushing the contaminated sediments during the flood period was eliminated. Drainage return flow to the Nile result into an increase in salinity of the water from 130 mg/l at Aswan (far upstream) to 250 mg/l near the delta barrage. Nitrogen fertilizers which consumption has doubled between 1980 and 1993 present another source of pollution. Water hyacinth flourishing at the downstream of water ways due to increased nutrients lead to clogging of canals and is combated with mechanical and biological technologies. Despite of the flourishing fish production in Egypt, only 17 species remain as of 1995 out of the 47 species which had been identified in 1948.

4. Water sector governance in Egypt

Three major governmental entities influence the management of water resources in Egypt. These are: (i) The Ministry of Water Resources and Irrigation, (ii) The Ministry of Agriculture and Land Reclamation, and (iii) The Ministry of Housing. The former is in charge of development, distribution and management of water resources, and development and O&M of the associated water works. The Ministry is also responsible for collection and disposal of agricultural drainage water, monitoring and assessment of water quality of the various water sources, and protecting the coastal lakes and the shoreline. The Ministry of Agriculture and Land Reclamation (MALR) is involved in improving agricultural activities and land reclamation, including water management at the on-farm level. The Ministry of Housing, Utilities and New Communities (MHUNC), provides water supply and sanitation services to the municipal and industrial subsectors. Some other ministries participate by different degrees in auxiliary management and operation of part of the irrigation and drainage systems such as Ministry of Health and Population (MoHP), the Ministry of State for Environmental Affairs, and the Ministry of Local Development (MoLD). Figure 6 represents the structure of MWRI.

Figure 6 – Institutional setup for MWRI



Source: CEDARE, 2011

5. Existing national water policies and strategies

Five main socio-economic sectors are dependent on the available scarce water resources for their development; namely the agricultural, industrial, municipal, navigation, and power generation sectors. The cultivated and cropped areas have been increasing over the past few years and will continue increasing due to the Government policy to add more agricultural lands. The largest consumers of irrigation water are Rice and Sugarcane because they have high water requirements in addition to occupying a considerable area. The average crop consumptive use for year 99/2000 was estimated to be 41.441 bcm. The total diverted water to agriculture from all sources (surface, groundwater, drainage reuse, and sewage reuse), which includes conveyance, distribution, and application losses, in 99/2000, was about 60.731 bcm. The water policies of the 1970's and early 1980's gave a significant advantage to new lands development. However, recent changes in price and other policies particularly the reduction/elimination of government fertilizer and energy subsidies place farmers in the new land at a disadvantage (ICID 2004).

During the seventies and early eighties of the last century policies have been directed towards water supply management. At present, integrated water resources management, which seeks an efficient blend of all available resources (fresh surface water, ground water, precipitation and drainage water) to meet demands of the full range of water users (including agriculture, municipalities, industry and in-stream flows) is becoming an integral part of MWRI's policy vision to meet these challenges. An extensive coordination effort among concerned government institutions and the active participation of water users in planning, management and operation of water collection and distribution systems is required. Integration also necessitates the establishment/enhancement of the legal basis for water allocation, conservation and protection as well as user participation in water management. To cope with these challenges, the MWRI has developed a national policy with four major pillars of: 1) increasing water use efficiency; 2) water quality protection; and 3) pollution control and water supply augmentation and 4) Institutional restructuring (NWRP 2004).

6. Challenges and responses

At present, there are significant challenges to water resources development and use in Egypt. Beginning with a single source of water – The Nile – uncertainties in climate, developments upstream, and population growths have characterized efforts to anticipate potential future water constraints. Municipal and industrial water use is being readily met and agricultural water use yields high levels of production with about 200% cropping intensity. However, the costs for water services for the next 15 years will be more than triple the current expenditures. Future public sector allocation for such high costs presents a heavy and unsustainable burden for the government budget. Moreover, water quality in a closed system is deteriorating because of pollutants being retained in as part of the recycling and reuse of drainage water, along with poor treatment and regulation of urban and rural sanitation. Stakeholders at the local level are organizing water users associations and water boards to confront the issue and have their voices heard on irrigation and rural sanitation issues.

Thus, the main drivers for water management reform at both the central and regional levels include (i) the need to meet supply/demand imbalances for the future; (ii) water quality deterioration and associated health and environmental risks; and (iii) weak service delivery, reliability, and transparency and associated quantity and quality measurements along with financial sustainability and cost recovery issues.

In addressing the main issues and the way forward, The Minister of Water Resources and Irrigation has stated in 2003 that: "…the challenges facing the water sector in Egypt are enormous and require the mobilization of all resources and the management of these resources in an integrated manner. This is especially true as the amount of available water resources is fixed; meanwhile water demands continue to grow in the years ahead due to population growth, increased food demand, and expansion and modernization of the industrial base, and improved standards of living."[1]

7. Status of freshwater resources and the water sector

Currently, freshwater resources in Egypt are still mainly attributed to the Nile. Additional resources include fossil groundwater, limited rainfalls along the northern coast and flash floods along the Red sea coast and in the Sinai Peninsula. The alluvium aquifer beneath the delta is annually recharged from the irrigation water in excess to plant needs. Egypt receives about 97% of its fresh water from the Nile, originating outside its international borders; at the Ethiopian plateau and the equatorial plateau. This is considered a major challenge for Egyptian water policy and decision makers. The average annual yield of the river is estimated at 84 BCM at Aswan, south of Egypt. However, Egypt's share from the Nile is fixed at 55.5 BCM per year by the 1959 agreement with Sudan.

The availability of fresh water resources is jointly governed by hydro-climatologically features as well as social, economical and political factors. Population densities and geographic distributions along with existing cropping patterns, uniformity in irrigation coverage[2] , and farmer's behavior[3] are major social factors. Economic factors indicate that about ten years ago (2001) agriculture has been contributing to 83% of the national water demands while providing 16% of the GDP and employing near 50% of the labor force in rural Egypt. Throughout ten years of prevailing water scarcity, these figures have been declining due to increased demand of other sectors with higher net added value of water. Political factors display additional pressures on the government to maintain its irrigation water subsidies to control further rural to urban migrations, Gharib (2004).

Other important parameters in defining the national status of water resources include water quality, accessibility, and reliability of water supply. An essential distinction has to be made between the water potential yield and the water development potential. The former refers to the availability of water resources whether it is stream flows, groundwater reservoirs, or directly exploited atmospheric water (necessary to

[1] Seminar on Implementing Integrated Water Management in Egypt, Agenda and Briefing Notes, 12-13 June 2003, p. iii
[2] For example between head and tail waters
[3] For example expansion of low duration rice with less water requirements is still limited due to its non-traditional taste with respect to farmers

produce natural vegetation/forest covers). The water potential yield is readily defined in many sources as internal (or actual) renewable (or non-renewable), or merely available, water resources. These figures are used in calculating per capita shares, defining water stress and water scarcity limits, etc. On the other hand, the water development potential takes into account the dependability of the flow, time and spatial distributions, feasibility of extraction of groundwater, and the availability of surface water post floods, navigation considerations, environmental and aquatic life minimum requirements.

About 20% of rural population in Egypt is classified by the national human development report (2003) as poor with about 6% categorized as ultra poor. Poor farmers with minute land ownership are pushed to cultivate low-cost crops, and within a free cropping pattern national policy, such cultivations have usually the least return per unit of applied irrigation water.

Decisions for optimal water allocations between different sectors, at the national level, should target maximum socio-economic benefits. While evaluating mega national programs, including extended agricultural development, the net social benefits are most likely maximized when the incremental net water value is the same in all uses. Such value is also referred to as the opportunity cost of moving water from one sector to another (or from one region to the other[4]). Furthermore, it is least likely that farming in the old lands will recognize opportunity costs of water in the industrial / service sectors pumping from below-tertiary canals should be the only cost for water. On the other hand, Hellegers & Perry (2004) show that volumetric pricing is unlikely to be relevant to demand management because the price of water at which demand and supply would be balanced is so high as to substantially reduce farm incomes. This socio-political problem, plus the technical and administrative complexity of measuring and accounting for water, and the crucial distinction between water applied to the field and water consumed by the crop make water pricing an unsuitable approach to balancing supply and demand. Nevertheless, availability of land, labor, and capital are major inputs to any national socio-economical model (and policy) seeking an optimal water allocation for future agricultural development (production, processing and marketing). Such facts have been long recognized by several experts, for example Wichelns (2001) and Elarabawi et al (2000).

Where excess water is recovered elsewhere in the system through drainage reuse or groundwater pumping, and this is the case to a large extent in the old lands in the Nile Valley and the Nile Delta, increasing the price of applied water may have little impact on consumption. Furthermore, the impact that volumetric pricing may have on demand will be limited if a quota system is in place, Wichelns (2001).

8. The agricultural system in Egypt

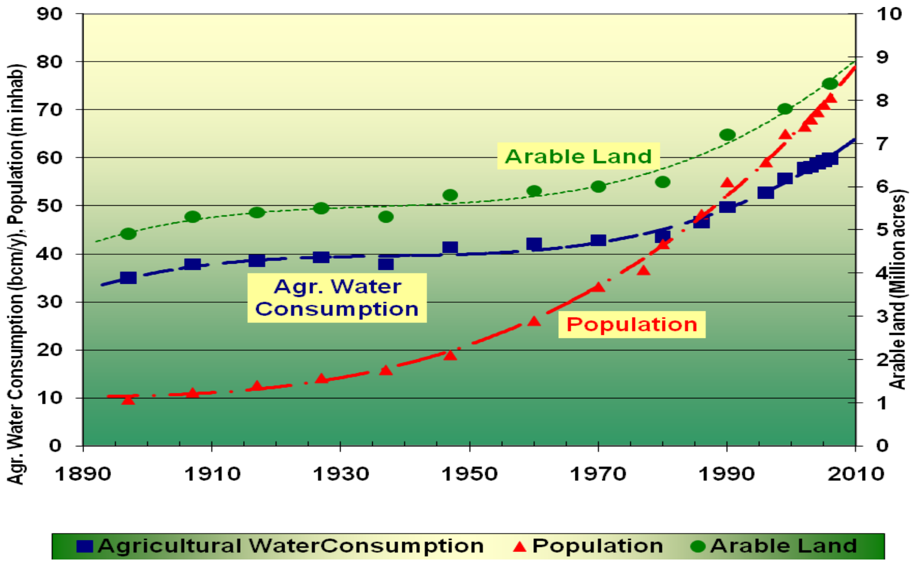
The Egyptian agricultural year starts in April and comprises three seasons; (i) Winter season: Dec 1st to Apr 1st, (ii) Summer season: Apr 1st to Aug. 1st, and (iii) Flood season (Niley): Aug 1st to Dec 1st. Main summer crops are corn, cotton, rice and sugarcane. Main winter crops are wheat, clover, barley and beans. Corn fodders and vegetables are usually grown during the Niley season. Before construction of the high Aswan dam, the winter season used to be the primary production season following the flood. Perennial irrigation following the dam construction in 1960 resulted in maximum water consumption for the summer season. Furthermore, crops for one season are frequently sown before those of the previous season have been harvested. Thus more than half of the Delta lands are providing yields for 2 to 3 crops annually. Nevertheless, close correlation between the agricultural seasons and the natural flooding cycles still exists suggesting potential impacts on crop yields corresponding to climate change impacts (temporal and special) on the Nile flooding and even more severe impacts corresponding to more frequent occurrence of extreme events and abnormal temperature variation waves (mainly heat and windy waves during spring).

Current (2010) cultivated land is about 8.5 million Feddans (one feddan measures 4200 m2 and is roughly equivalent to one acre) where about 75% belong to the old lands in the Nile Valley, Delta and its peripheries. These lands mainly apply traditional surface irrigation techniques consuming about 87% of the total irrigation demand. Newly reclaimed lands in several desert areas apply sprinkler and drip irrigation

[4] For example when comparing agricultural expansion in the south (Toshka) to that in Sinai and its relative advantage/disadvantage to old lands in Delta.

techniques, while conveyance is mainly through lined channels. The total cropped area is equivalent to about 14.2 million feddans with an average national intensification factor of 1.75 (where average land produces more than one crop annually). Figure 7 shows the development of arable lands throughout the last century along with corresponding irrigation water demands showing an increase in arable lands of about 2.3 million feddans between 1980 and 2010.

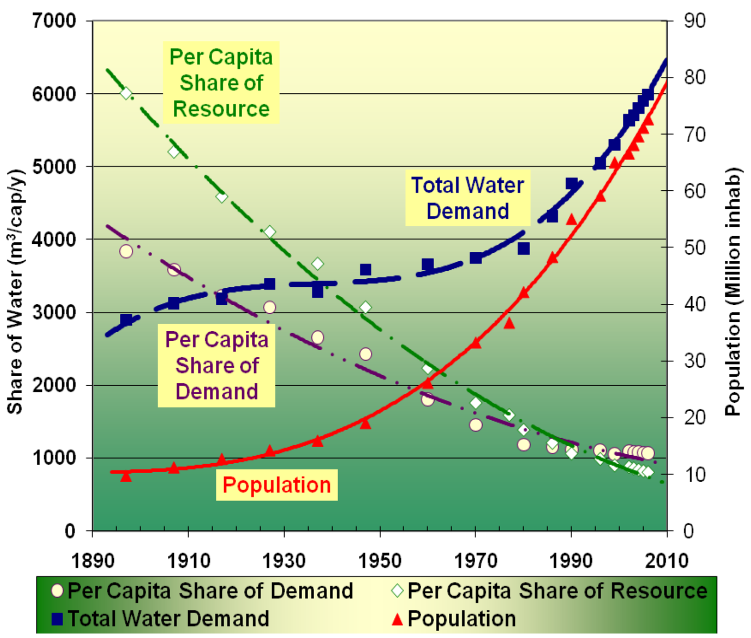
Figure 7 - Agricultural Water Demands throughout a Century



Source: CEDARE, 2011

Figure 8 shows an increase in total water demands in Egypt from about 47 BCM/yr in 1960 to near 77 BCM/yr in 2010 and corresponding decline in per capita shares of water resources from 2220 m³/cap/yr to 760 m³/cap/yr and another decline in per capita shares of demand from 1800 m³/cap/yr to 1000 m³/cap/yr. The 5-years average cropping pattern show that 45% of the agricultural yield in Egypt is produced during the winter season, 40% during the summer season, 4% during the Niley season, while permanent cultivations (fruits, sugarcane, horticulture, etc) represent 11%, MALR, National Program for optimal water use in old lands (2008).

Figure 8 - Annual per capita Shares throughout a Century



Source: CEDARE, 2011

II. The water efficiency index

The methodology proposed by the Blue Plan for evaluating the water efficiency is first briefly presented. The current national status of the three main water subsectors is then discussed. The best estimates for sectoral efficiencies along with overall water efficiency in Egypt are projected. Proposed interventions to improve data collection for better efficiency monitoring are finally recommended along with its associated cost estimate.

1. The agricultural sub-sector

The basic concept of irrigation efficiency, Ie, was set forth by Israelsen (1950) as the ratio of the irrigation water consumed (evaporated) by crops, Uci, to the irrigation water delivered from a surface or groundwater source to the canals or farm head gates, VD:

$$\mathbf{Ie} = \frac{\mathbf{Uci}}{\mathbf{VD}} = \frac{\mathbf{Cr\square p\ ET - Pe}}{\mathbf{VD}}$$

As early as the late seventies, many researchers recognised that the direct application of classical field efficiency for measuring national or regional irrigation efficiencies may be highly misleading. Jensen (1977) and Jensen et al. (1980) acknowledged the fact that the classical field efficiency concept is commonly misapplied in resource development because the recovery of the irrigation water is ignored. Keller (1992), (1995) indicate that classical water use efficiency concepts are appropriate tools for irrigation design and irrigation management, but they are poorly suited for formulating water allocation and transfer policies. Classical efficiency concepts ignore the value of return flows—irrigation water runoff and seepage that re-enters the water supply. Consequently, decisions intended to raise water use efficiency that have been based on classical efficiency calculations often do not result in real water savings. Alternatively, they introduced the concept of effective irrigation efficiency, Ee, which takes into account both the quantity and quality of the water delivered from and returned to a basin's water supply when estimating the total freshwater input for each use-cycle. In other words the effectiveness of irrigation water is reduced after each re-use cycle according the prevailing salinity in mixing water.

The methodology for estimating irrigation efficiency as proposed by Blue Plan is summarized as:

- The physical efficiency of irrigation water is the product of "network for irrigation water transport and distribution" efficiency by plot efficiency:

$$\mathbf{Eirr = E1 \times E2}$$

  - E1: efficiency of irrigation water transport and distribution networks, upstream from agricultural plots, measured as the ratio between water volumes actually distributed to plots (V3) and the total volume of water for irrigation (V4), upstream of networks, including losses in networks ;

$$\mathbf{E1 = V3/V4}$$

  - E2: plot irrigation efficiency is defined as the sum of efficiencies (per plot) of all irrigation modes (surface irrigation, sprinkler irrigation, micro-irrigation, others), weighted by the respective proportions of all local modes and estimated as the ratio between water volumes actually consumed by plants and volumes delivered to plots:

$$\mathbf{E2} = \sum_{1}^{n} \frac{Sm \times Em}{S}$$

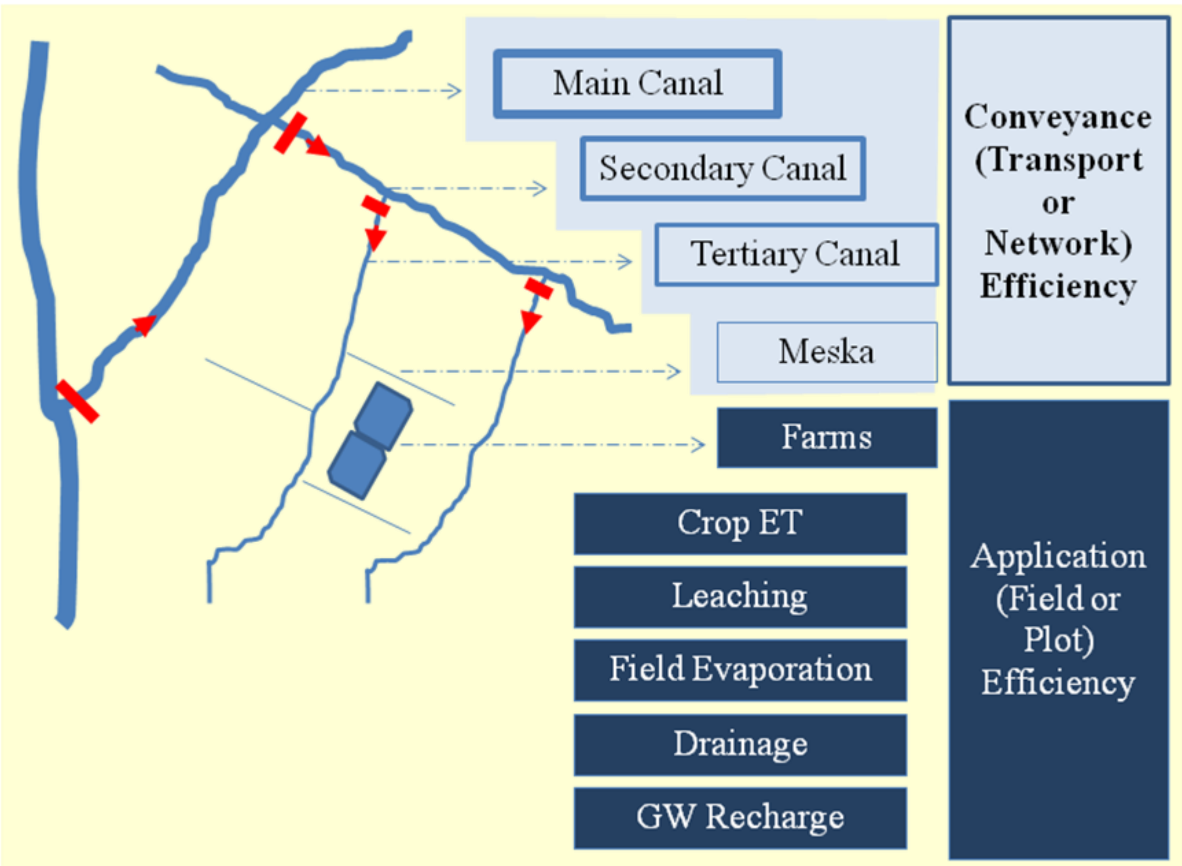
  - n : number of irrigation modes used:
  - Sm: surfaces irrigated using modes : m
  - Em: method efficiency: m
  - S : total local irrigated surface according to different modes

Prior to applying any methodology for estimation of the national irrigation efficiency, a broad layout for the Egyptian irrigation system is presented as shown in Figure 9. Water is initially released from high Aswan dam reservoir into the Nile as per an operational policy which corresponds to annual demands (including hydro power generation) as previously depicted from Figure 3. The Nile is harnessed by major control structures (barrages). The Nile supplies main canals which in turn deliver their water to secondary canals. The latter feed tertiary canals and meskas, which supply field irrigation water through low head pumping. Intermediate stages of the network are subject to extensive recycling through mixing with agricultural drainage water, domestic (and industrial) wastewater (primary and secondary treated), and through mixing with groundwater near the tail ends. Throughout the 31,000 km-long distribution network, part of water is lost to the atmosphere by evaporation while another part is lost from the conveyor (yet is NOT lost from the system) through seepage. Fields also apply supplemental (or sometimes total reliance on) irrigation through groundwater extracted from the Nile alluvium aquifer which is recharged annually through seepage from irrigated fields and conveyance network.

At the field level, water is beneficially extracted through:

- Crop ET,
- Leaching excess salts and feeding drains, which is beneficial since it will be eventually used, more than once, by other downstream fields after being mixed with fresh canal water. While the water quantity is preserved, its quality is constantly deteriorating as we move downstream (thus its effectiveness is decreased, should we follow Keller's conceptual system),
- Deep percolation (which is also beneficial since it will be reused again at another plot, otherwise the Nile aquifer would have been depleted).

Figure 9 - Schematic layout for the irrigation system in Egypt and the main components for estimating conveyance and field efficiencies



Source: CEDARE, 2011

Local or field evaporation due to temporary pounding and temporary presence of excess soil moisture within the root zone represent the only real losses from the main system. The previous conceptualisation applies for the old (alluvium) lands. In these lands traditional surface irrigation is predominant (95%). Newly reclaimed lands, mainly in desert areas don't belong to a closed system and recycling is not an option. Thus in such system, any drop of water which is not captured by the plants is considered as a real loss (excluding land treatment requirements). The new lands enjoin, by law, modern irrigation methods, mainly drip irrigation and low level sprinkler systems. These mainly depend on groundwater (basically fossil waters from the Nubian aquifer and the Moghra aquifer) for their water supplies. Supplemental surface water may be also present (for example the new West Delta Project) conveyed through lined channels. Thus, while the Blue Plan's approach to calculate irrigation efficiency best suits the newly reclaimed lands, it will generate misleading indications should it be applied to the old lands. Keller (1995) indicates that Egypt's Nile Valley irrigation system is an excellent example of a multiple use-cycle system with a high global efficiency (near 90%) but low local efficiencies (around 45%). Egypt is interested in expanding the area irrigated by Nile River waters without reducing the high productivity of the present irrigated areas. They add that directing conservation efforts toward areas where multiple use-cycles are possible, and thus global efficiency is already high, will result in little real water savings. To achieve real water savings, either the cropland losses to evaporation, Uci, or the losses to phreatophytes must be reduced, and both would be costly.

1.1. Conveyance (transport or network) efficiency

Following the national water demands distribution in Figure 3, Agricultural demand is about 60 BCM/y. Old lands demands are estimated at 52 BCM/y (following estimates by FAO (2007), NWRP (2005), MALR (2005), CAPMAS (2007) and others). About 22% of this demand is satisfied through recycling and reuse of mixed agricultural drainage water and treated wastewater. Regional and temporal irrigation water distributions are given in Table 1 which shows that Upper Egypt (the most upstream region) receives about 19% of the total irrigation water distributed to agricultural fields. Lower Egypt (the most downstream Delta region) receives about 64% of the total irrigation water delivered at field (through meskas and tertiary canals). Moreover, summer crops receive more than 52% of total irrigation water compared to 33% for winter crops and about 10% for permanent crops (mainly fruit trees).

Furthermore, about 65% of the total conveyance leakage and evaporation occur within the Lower Egypt delta region, due to the intensified density of irrigation network as compared to Upper Egypt which contributes 20% of total conveyance losses[5].

Tiwari and Dinar (2002) estimated the conveyance losses between main canals and outlets to be 25% and between outlets and fields to be 11%. A 10 BCM is estimated to be network losses. Gharib (2004) states that the Ministry of Water Resources and Irrigation in Egypt estimates conveyance efficiencies at 70% and 80% for old and new lands respectively. Corresponding application (field or plot) efficiencies are estimated at 80% and 90%. The overall efficiency, for old and new lands together, considering reuse, is estimated at 75%.

[5] The word losses is used in the apparent sense only, following our previous discussion regarding beneficial losses

Table 1 - Temporal and regional distribution of irrigation water and associated leakage / evaporation from conveyance network

Region	Seasonal Crops	Distribution of Conveyed Irrigation Water			Conveyance Leakage and Evaporation	
		Field (% of total field water)	Canal Heads %	Aswan water release %	Between field and canal head (%)	Between field and Aswan (%)
Lower Egypt	Winter	20.1	19.2	19.1	14.9	17.5
	Summer	35.2	36.4	38.3	43.1	44.1
	Niley	1.4	1.4	1.3	1.4	1.1
	Fruits	7.3	7	7.1	5.6	6.6
	Sub Total	64	64	65.8	65.1	69.3
Middle Egypt	Winter	7	6.8	6.7	5.3	6.1
	Summer	6.3	6.4	6	6.3	5.2
	Niley	2	2	1.9	2.1	1.6
	Fruits	1.8	1.8	1.8	1.4	1.7
	Sub Total	17	17	16.4	15.2	14.7
Upper Egypt	Winter	5.9	5.7	5.5	4.5	4.6
	Summer	11.1	11.5	10.7	13.9	10.0
	Niley	1	0.5	0.5	0.5	0.4
	Fruits	1	1.1	1.1	0.9	1.0
	Sub Total	19	18.8	17.8	19.8	16.0
Total EGYPT	Winter	33.1	31.7	31.3	24.7	28.2
	Summer	52.7	54.4	55	63.3	59.3
	Niley	3.9	4	3.7	4.1	3.1
	Fruits	10.3	9.9	10	7.9	9.4
	Total	100	100	100	100	100.0

Source: Adopted from CAPMAS (2007)

Table 2 displays the national irrigation water volumes for the year 2005, estimated: (i) at fields, (ii) at canal heads and (iii) as released from Aswan, as adopted from the CAPMAS (2007) report. The figures for temporal and regional shares from Aswan release are subject to double counting flaws and are therefore adjusted. Furthermore, the measured difference in volumes between field and canal heads (or Aswan) should be normalised with the total irrigation water including release, since the latter is the actual volume flowing through the irrigation network. To account for such error, and while considering a 0.22 reuse factor, the total conveyance efficiency figures (between field and Aswan) need to be multiplied by an average factor of 1.08 (reflecting more intensified reuse at downstream than at upstream). The result is displayed in Table 3 which shows an average network efficiency of 76.3% with a minimum of 73% in summer and about 81% for winter seasonal crops.

Table 2 - Conveyance efficiencies for year 2005

Region	Seasonal Crops	Distribution of conveyed water (MCM/Yr)			Conveyance efficiency (%) (including leakage and evaporation)	
		At Field	At Canal Heads	At Aswan	Between field and canal head	Between field and Aswan (%)
Lower Egypt	Winter	5974	6816	8062	87.6	74.1
	Summer	10468	12911	16144	81.1	64.8
	Niley	419	500	548	83.8	76.5
	Fruits	2173	2492	2974	87.2	73.1
	Total	19034	22719	27727	83.8	68.6
Middle Egypt	Winter	2106	2406	2840	87.5	74.1
	Summer	1901	2259	2519	84.2	75.5
	Niley	605	723	793	83.7	76.3
	Fruits	561	643	771	87.2	72.8
	Total	5173	6031	6923	85.8	74.7
Upper Egypt	Winter	1770	2024	2299	87.5	77.0
	Summer	3314	4100	4516	80.8	73.4
	Niley	152	183	201	83.1	75.7
	Fruits	332	381	457	87.1	72.7
	Total	5568	6688	7472	83.3	74.5
Total EGYPT	Winter	9850	11246	13202	87.6	74.6
	Summer	15683	19270	23179	81.4	67.7
	Niley	1176	1406	1541	83.6	76.3
	Fruits	3066	3516	4201	87.2	73.0
	Total	29775	35438	42122	84.0	70.7

Source: Adopted from CAPMAS (2007) after adjustment to eliminate double counting.

Table 3 - National Conveyance efficiencies considering reused water

Season Crops	Winter	Summer	Niley	Fruits	Total
Efficiency E1 (%)	80.6	73.3	82.4	78.8	76.3

Source: CEDARE, 2011

1.2. Application (field or plot) efficiency

Newly reclaimed lands are estimated by MALR (2008) at 2.5 million feddans applying modern irrigation techniques mainly sprinkler and drip irrigation. No reliable distinction between the areas subject to each specific irrigation type has been provided and it is assumed that each type pertain to an area of 1.25 million feddans. MALR (2008) estimates sprinkler application efficiencies at 75% and drip application efficiencies at 85%. Accordingly, for the new lands, the application efficiency is evaluated at 80% for 2.5 million feddans. This corresponds to about 29% of the total cultivated area, yet about 19% of the total cropped area due to the fact that the crop intensification factor in these lands is near unity.

In old lands, traditional surface irrigation techniques are dominating with only 5% of land subject to modern irrigation (mainly improved surface irrigation and drip-type). Application efficiencies for both types are estimated at 60% (averaging a wide range of estimations by ICID, MWRI, MALR, FAO, and others) and 75%. The average application efficiency, following the Blue Plan approach is thus calculated as follows:

$$E_2 = \sum_{1}^{4} \frac{S_m E_m}{S} = \frac{1.25(0.75) + 1.25(0.85) + 5.7(0.6) + 0.3(0.75)}{8.5} = 0.6647 = \quad 66.5\%$$

1.3. Overall irrigation efficiency

The overall irrigation efficiency (Eirr), following the blue plan approach is thus calculated as:

$$E_{irr} = E_1 E_2 = (0.763) \times (0.665) = \mathbf{0.51}$$

It should be noted here that increasing the overall efficiency by about 21%, to reach 72% as targeted by the Blue Plan's scenario for water savings by 2025, does not guarantee, by any means, that the corresponding water savings will account for 21% of the current irrigation water volumes. Thus, for example, the current irrigation demands under the current prevailing efficiencies are about 60 BCM/yr. Let us assume that appropriate measures are taken to reduce conveyance losses (leakage and evaporation) and also to reduce field (plot) losses (drainage, groundwater recharge, and evaporation) such that the overall irrigation efficiency reaches 72% according to Blue Plan's definitions. These measures will NOT result in a net water saving of 60 x 0.21 = 12.6 BCM/yr. In fact the net actual saving from a national prospective will only be a fraction of this figure (probably no more than 2.5 BCM/yr) corresponding to reduction in evaporation. Furthermore, the detrimental impacts resulting from major reductions in Nile aquifer recharge and drainage water (accelerated soil salinization, advancement saltwater/freshwater interface inland) may greatly reduce the benefits corresponding to additional water saved. This will be further expanded in the last part of this report.

2. The drinking water sub-sector

The drinking water efficiency is estimated according to the Blue Plan (Epot) as:

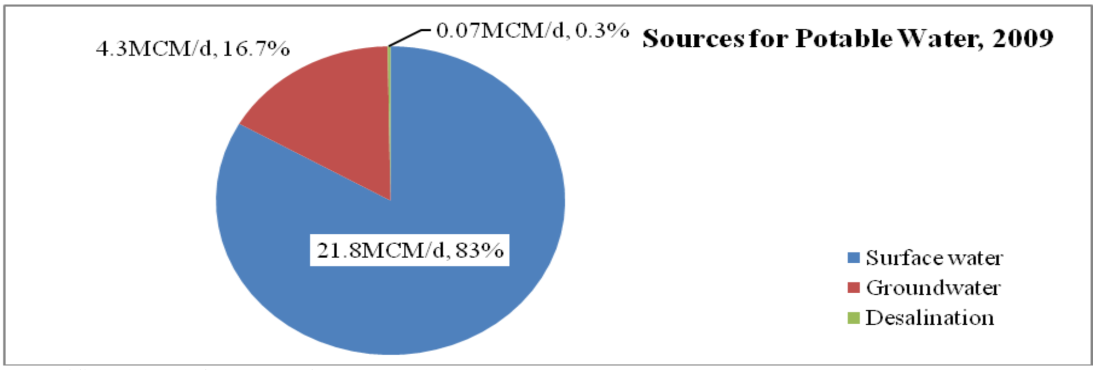
Epot = V1 / V2 where

- V1 = drinking water volume invoiced and paid by consumer in km^3/year
- V2 = total drinking water volume produced and distributed in km^3/year (drinking water demand)

The indicator measures both the physical efficiency of drinking water distribution networks (loss rates or yield) and economic efficiency, e.g., the capacity of network managers to cover costs through consumer payments.

The total amount of produced potable water in 2009 reached about 9.5 BCM/y. Figure 10 shows that 83% of this amount is extracted from surface water (Nile and main canals), and about 16.7% is extracted from shallow and deep groundwater aquifers. Desalination accounts for about 70,000 m^3 /d.

Figure 10 - Potable Water Sources

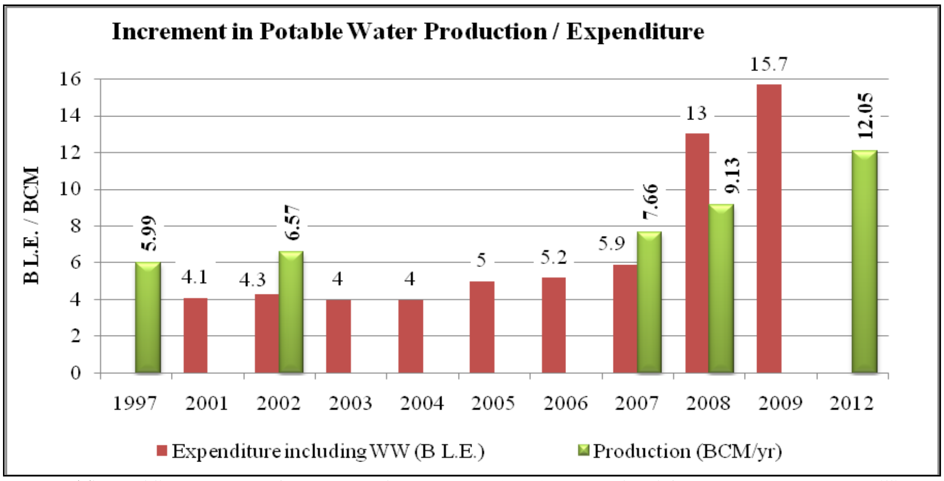


Source: Holding Company for Water and Wastewater (2010)

Figure 11 shows the national progress in water supply services and its associated costs. Potable water production has increased steadily from about 6 BCM at 1997 to 15.7 BCM in 2009. Future plans include the production of about 12 BCM of potable water by 2012 which satisfies the demand till 2030 assuming that total losses will be reduced to 15% by then.

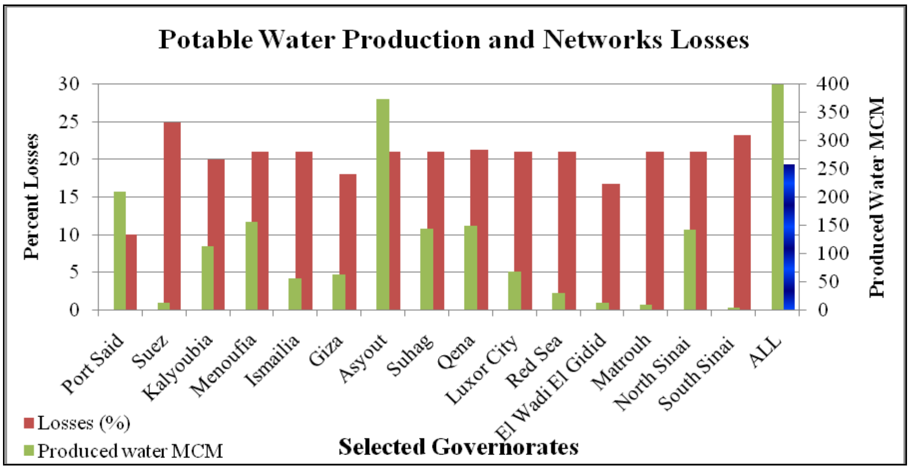
The drinking water efficiency is first measured for the year 2005 where data is provided by CAPMAS (2007). Figure 12 shows the volumes of water produced and the percent lost during conveyance for selected governorates where a 25% average loss is envisioned. Maximum losses occur in Fayoum Governorate (about 35%) while minimum losses (10%) occur in Port Said which is usually rated between highest and second highest in average annual income per capita in Egypt. The case of Alexandria Governorate is presented separately in Figure 13 where data has been more readily available. The figure shows a small, yet steady, decrease in overall losses (network leakage and economic efficiency) between years 2005 and 2008 where the losses dropped from 39% to 35%.

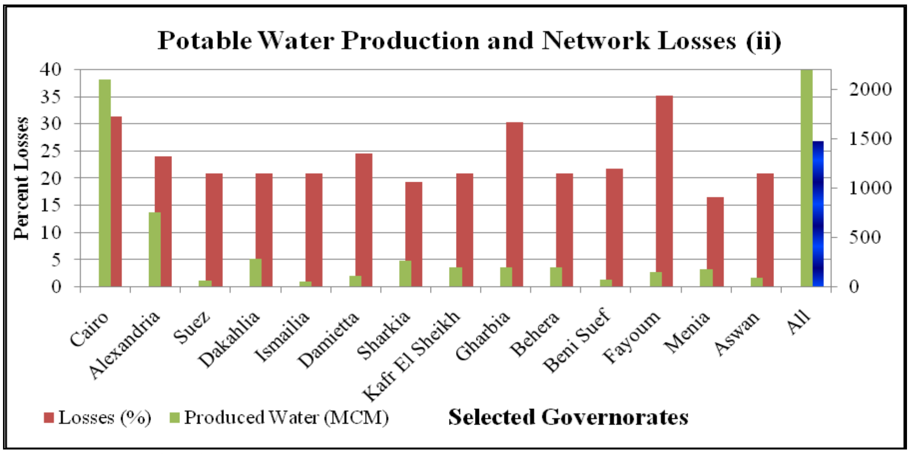
Figure 11 - Progress in Potable Water Production along with Expenditures for improving potable water and sanitation Services in Billion Egyptian Pounds



Source: The Holding Company for Water and Wastewater (2010) Extrapolated from Nov. – Dec. 2009 Billing Statement.

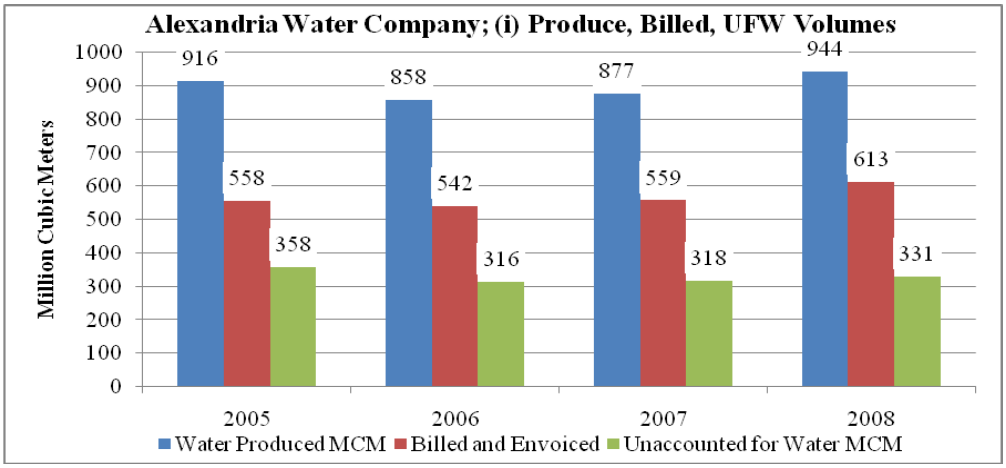
Figure 12 - Values for Produced Potable Water and Conveyance Losses for Selected Governorates for the year 2005

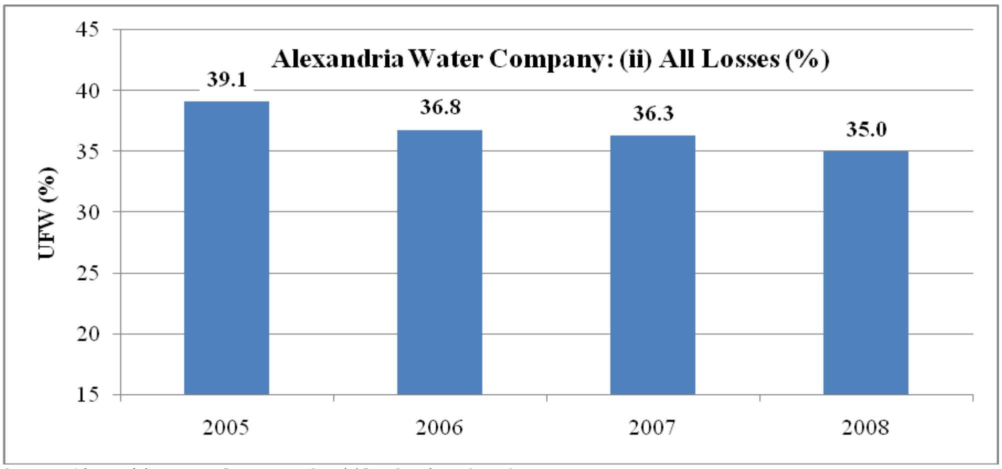




Source: CAPMAS (2007)

Figure 13 - 2005 to 2008 Measured Values for: (i) Produced and Invoiced Potable Water Volumes, and (ii) Total Losses (Conveyance Losses, Uncharged Services, illegal connections) for Alexandria Governorate



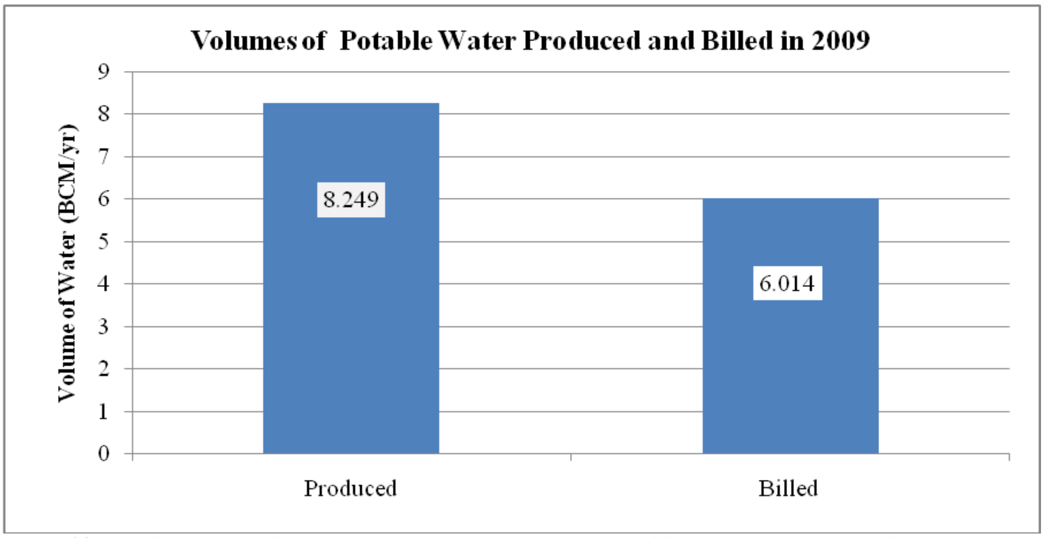


Source: Alexandria Water Company; SWITCH Seminar (2009)

The accumulative annual volume of billed drinking water (V1) in 2005 is equal to 5.395 BCM while the total volume of produced water (V2) has been 7.179 BCM. Thus the efficiency of drinking water:

$$\mathbf{Epot = 5.395 / 7.179 = 0.75}$$

Figure 14 - 2009 Measured Values for Produced and Invoiced Potable Water Volumes



Source: The Holding Company for Water and Wastewater (2010) Extrapolated from Nov. – Dec. 2009 Billing Statement.

Furthermore, referring to the billing statements for the last two months in 2009, Figure 14 shows that in 2009:

$$\mathbf{Epot = V1 / V2 = 6.014 / 8.249 = 0.73}$$

3. The industrial sub-sector

The industrial water use efficiency is estimated according to the Blue Plan through the calculation of the recycling index (Eind) as:

The volume of recycled industrial water (recycling index):

Eind= V5 / V6, where:

- V5 = Recycled water volumes in km^3/year.
- V6 = Gross volume consumed for industrial processes which is equal to the volume incoming for the first-time to the industrial plant + recycled volume in km^3/year.

Data pertaining to actual industrial water demands are scarce and controversial. Industrial water demands are satisfied through three sources:

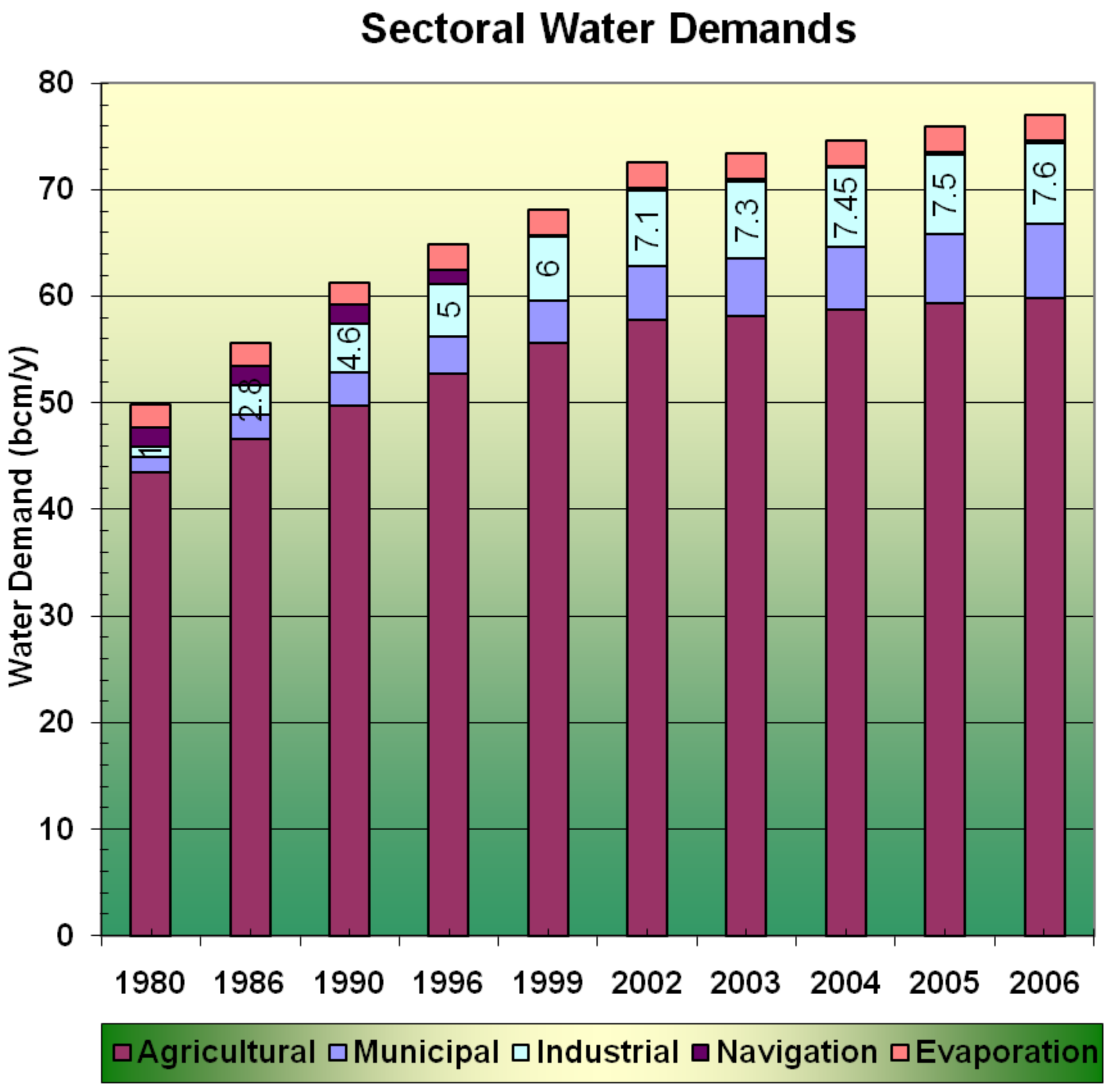
- Extractions from surface water; which requires a permit from the Ministry of Water Resources and Irrigation, thus this part is well documented and currently (2009) estimated at: 1.25 BCM/yr as compared to 1.1 BCM/yr in 2001. The figures, in itself are not indicative of an industrial sector which is growing at an annual rate of 5 to 8% throughout the given period. It is also indicative of the possible incidents of uncharged/illegal water withdrawals, particularly from factories belonging to the governmental sector.
- Extractions from groundwater; which, by law, also requires a permit from the Ministry of Water Resources and Irrigation, yet a considerable proportion of extracted groundwater is not registered or permitted due to weak enforcement of legislations.
- Connections to the potable water distribution network: where this part is estimated at 1.15 BCM/yr following detailed billing accounts at selected locations (for example Alexandria).

FAO AQUASTAT estimates industrial use in 2005 at 4.1 BCM (probably excluding cooling water). World Bank indicators WBI (2005) provide an estimate of 5.86 BCM for the year 2007[6]. AbdelGawad, S. (2004 & 2008) states that Municipal and industrial uses account for 15% of the total water consumption in the country, while navigation and hydropower generation are considered as non-consumptive uses. Industry and mining account for nearly 18% of the GDP and almost 14% of total employment. Furthermore, she estimates the total industrial abstractions as 7.5 BCM/yr where a small portion of this quantity (0.8 BCM) is actually consumed throughout the industrial processes, while the rest returns back to the system in a polluted form.

The total national water demands including industrial water demand is projected in Figure 15 reflecting inputs from previous references in addition to IDSC (2007) and NWRP (2005) and others. An abstraction of 8.0 BCM is anticipated for the year 2009 for all industrial uses. About 53% of the industrial water is abstracted directly from the Nile irrigation canals, 19% from the public networks and 28% from ground water.

[6] WBI also estimates a value of 8.3 BCM for the year 1993!

Figure 15 - Sectoral Abstractions and Anticipated Industrial Water Use between the years 1980 and 2006



Source: CEDARE, 2011

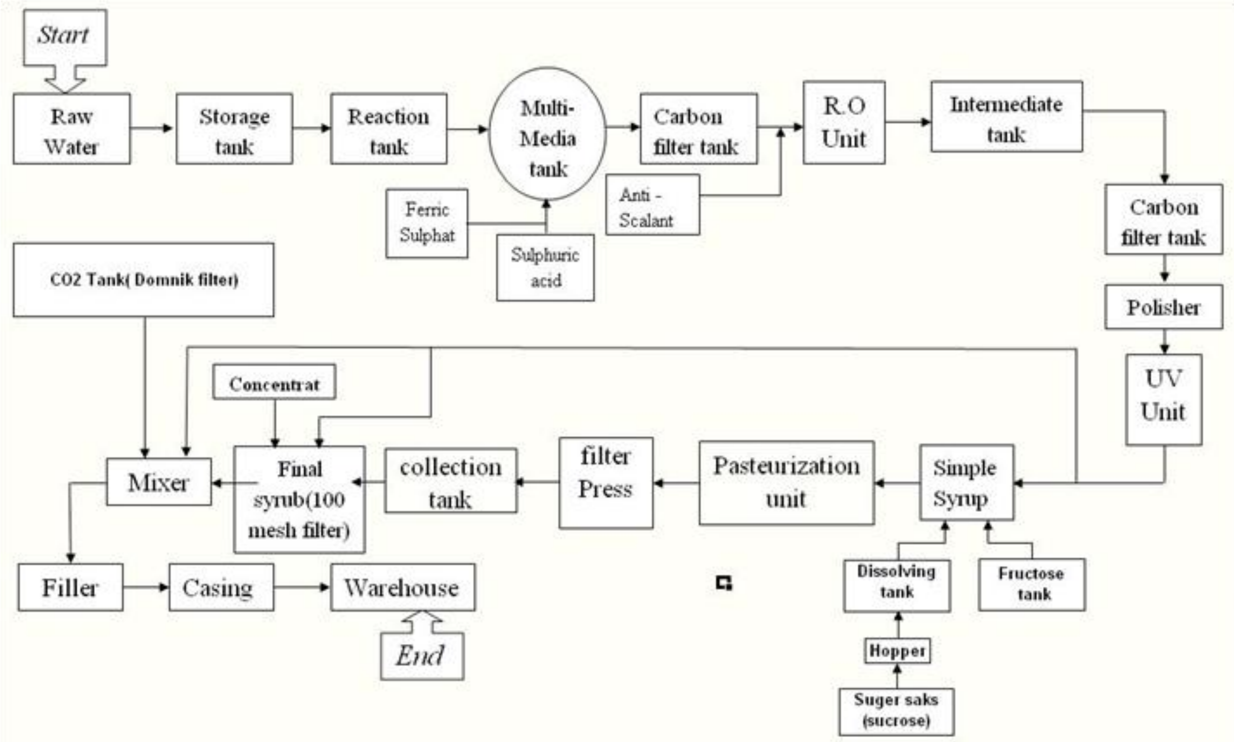
This industrial water is used for the following purposes, NWRP (2005):

- Process water 51%
- Cooling Water 43%
- Other Use 6%

The food processing and agro-industries along with the chemical industries are projected by NWRP (2005) to contribute to 80% of the total industrial consumptions. The volumes of water which are subject to recycling and reuse within the industrial sector are not readily documented or available. Accordingly selected industrial enterprises have been visited and interviewed to collect such data which has been considered as representative for the whole industrial sector in the absence of other information.

Two examples pertaining to the food and beverage sub sector are presented below. The first is related to the PepsiCo production, bottling and distribution enterprises in Egypt. The former is a good example for optimizing water use within the industrial sector. The industrial process is schematically presented in Figure 16.

Figure 16 - Schematic Diagram for Industrial Process, Pepsi Co (2010).



Source: CEDARE, 2011

The company has adopted a policy to maximize the return from unit processing water and to minimize losses through applying both: in-situ conservation techniques along with process shifting to more economical use of water. The total water consumptions for 7 plants all around Egypt has been reduced from about 6.0 MCM/yr for 2006 to 4.250 MCM/yr in 2009. 75% of this consumption is being supplied through potable water networks at a cost of 2.5 L.E. per m^3. Thus total saving of 1.776 million cubic meters of water equivalent to about 4.0 million L.E. is achieved. Water conservation policy applies the RRR principles; Reduce, Recycle, Reuse.

- Reduce: Awareness & participation across all levels at the plants water mapping.
- Recycle: Back wash recovery, bottle washer recovery, Rinser recovery. The cost of each project is depending on many parameters but the pay back is very short.
- Reuse: Use the output of 1 process to be input to the other one which needs a lower quality water (like cleaning the floors, cleaning the crates).

The volume of annually recycled water **V5 = 0.23 MCM** while the gross water used **V6 = 4.25 MCM**, and thus the recycling efficiency **Eind = 0.23 / 4.25 = 0.055 = 5.5 %**. This factor doesn't reflect the fact that there has been a **total water saving equivalent to almost 30% of the water used for production** due to the transformation of the water added value (in liters of water/liters of product) from **6.65 l/l to 4.7 l/l**!

The second example concerns Coca Cola concentrate and beverage base enterprise. The main industrial process involves the following:

Concentrate and Beverage base, mixing and diluting liquid and dry ingredients to form concentrates. Water is used and conserved (as related to 2005 status) as per 4 categories:

- Utilities: reducing steam boiler and water heater consumption by adding Heat Exchanger (HE) unit to use water at higher temperature usage rate subsequently reduces water consumption rates.
- Formula water

- Sanitizing and cleaning: improve 3 steps and five steps processes and increase detergent concentration to use less water in these processes
- Reuse wastewater, after treatment, in landscaping after aeration and neutralization and PH adjustment.

The results of this conservation program are the transformation of the water added value (liter of water per kilogram of product) from **7.4 l/kg to 2.39 l/kg**. The volume of annually recycled water **V5 = 0.016 MCM** while the gross water used **V6 = 0.038 MCM**, and thus the recycling efficiency **Eind = 0.016 / .038 = 0.42 = 42%.**

Extrapolating the previous results along with inputs from SEAM (1999) where a program for industrial pollution prevention has been adopted by the Egyptian Environmental Affairs Agency (EEAA) with support from DFID. The program addressed several industrial sub-sectors including Food, Oil & Soap, Textile industries and others. The program which implemented several interventions to mitigate negative impacts includes reduction, treatment and recycling of wastewater, reduction of total water and energy consumptions, and many others. Edfina and Kaha are enterprises for agro-industries producing frozen vegetables, juices, canned tomato paste, etc., with total production of about 20,000 tons of preserved food products at this time. Both factories have had an annual abstraction of 1.6 MCM/yr while discharging 1.3 MCM/yr. Water was used as: 56% for vegetable washing and processing, 35% for cooling and 9% for domestic purposes. SEAM implemented processes for enhancing efficiencies of Dowe pack recycling collection system, replacement of hose nozzles, installation of a cooling tower for sterilized juice bottles to replace existing open cycle municipal water for cooling and others. Capital costs for interventions is around 100,000 L.E. and resulted in a water saving of 120,000 m^3/yr and an overall annual savings of 119,000 L.E. with a payback period of about 10 months. The recycling efficiency for both factories is estimated as:

Eind = 0.12 / (1.6-.12) = .081 = 8%

Following the previous examples and assuming that non-cooling water constitutes 40% of total abstractions, and assuming agro-industries to consume 50% of total industrial demands, the overall national estimate for the recycling efficiency would be:

Eind = 0.17 / 3.04 = 0.056 = 5.6%

III. Improving water efficiency for different sectors

The main institutional structure governing the water sector will be first reviewed with particular emphasis on the drinking water subsector, since the agricultural sector has been previously covered. National polices strategies and targets for improving water efficiencies will be next introduced followed by a preview of programs and projects of direct relevance. Extended discussions of the National Water Resources Plan are also included.

1. Institutional Structure

Egyptian water sector policies are set by several ministries. The Ministry of Water Resources and Irrigation (previously called Ministry of Public Works and Water Resources) is the oldest ministry in Egypt. Its responsibility is to ensure that all users receive enough water. The Ministry of Housing, Utilities and Urban Communities supervises water authorities, which are responsible for the treatment and delivery of water. The Egyptian Environmental Affairs Agency is responsible for environmental affairs and the assessment and monitoring of water use. The Ministry of Health and Population is responsible for analyzing water quality. The Holding Company for Water and Wastewater was founded by decree in 2004, charged with responsibility for financial and technical sustainability to the local Governorate-based utilities. The latter will be addressed separately.

1.1. The potable water and wastewater governance

Table 4 - Water Tariffs in Alexandria, according to the type of use

S	Type of use	Price		Sanitation charges (% of total bill)
		Quantity (m^3)	Prices L.E. $/m^3$	
1	Residential	0 – 10	0.23	35
		10 – 30	0.30	
		> 30	0.40	
2	Construction works		0.80	70
3	Religious buildings and social associations(*)		0.42	35
4	Sports club, syndications, political parties, and Embassies		0.15	35
5	Social clubs		1.00	70
6	Small industrial firms, workshops, hospitals, private schools, and bakeries		0.70	70
7	Large scale industrial firms in Burg El Arab		1.00	70
8	Large scale industrial firms in El Amriah and Alexandria		1.50	90
9	Petroleum industrial firms		3.50	70 (If any)
10	Private hospitals, five star hotels, and recreation area		1.15	90
11	Soft drinks firms	-	1.00	70 (If any)

(*) Religious buildings and social associations receive a discount of 50% on official rates

The Water and wastewater sector in Egypt was operated as a governmental utility. The sector was suffering from technical, administration and financial problems including:

- Low water tariffs (among the lowest in the world); the water tariffs in the city of Alexandria are presented in Table (4)
- Overstaffing with inadequate personnel
- Absence of financial accountability

By the year 2000 water utilities had an accumulated operating deficit of $1.2 billion and a $1.1 billion debt. To resolve these burdens, the Government has decided to convert all the water and wastewater utilities into companies to be economically operated.

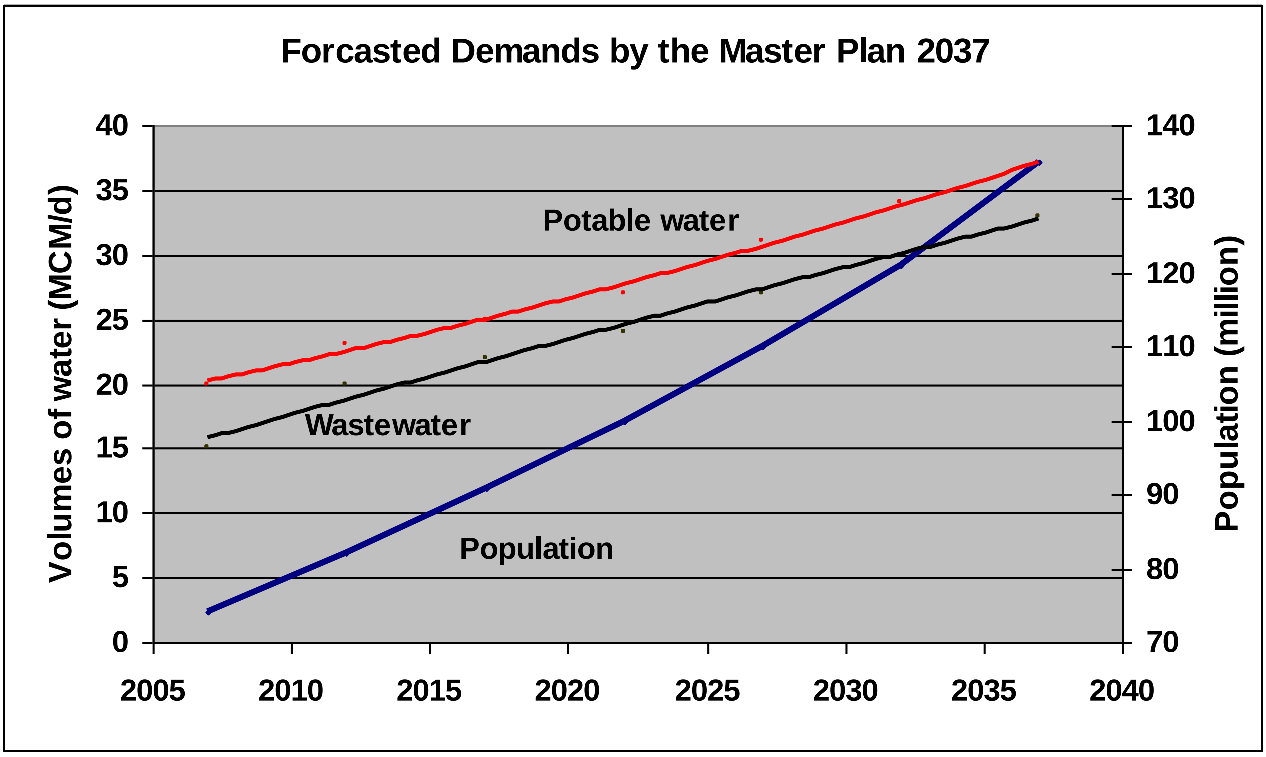
The Holding Company has been established in accordance with the Presidential Decree No. 135/2004. Throughout five years operation of the Holding Company most of the previous debt has been released through several interventions including: (i) Institutional re-structuring and relief of un-necessary human resources, (ii) Enhancing collection services, (iii) Doubling tariffs for domestic uses, a five fold increase in tariffs for industrial uses, applying new tariffs for wastewater equivalent to around 30% of water supply tariff for all uses, (iv) partial subsidizing by central government. General information pertaining to the Holding Company till February 2010 is summarized as follows:

- Scope of work : 25 governorates in addition to the city of Shubra El-Kheima
- Number of affiliate companies: 23 companies
- Number of staff of the affiliate companies: 98,500 employees
- Number of subscribers to Drinking Water services: 10 million subscribers
- Population served by Drinking Water services: 75 million inhabitants
- Production of Drinking Water: 23 MCM/d
- Treated wastewater: 8.5 MCM/d
- Number of potable water plants: 159 filtering plants, 774 small plants, 1709 GW-based plants, 23 desalination plants
- Number of water treatment plants: 150 filtering plants, 540 small plants and 878 well plants
- Length of distribution networks: 112,000 km
- Number of wastewater treatment plants: 310 plants
- Length of wastewater collection networks: 33,000 km

The company has produced the 2037 master plan. The aim of the master plans is to cover Water & Wastewater needs overall Egypt till 2037, in addition to the high priority projects and studying the different interventions & alternatives of funding. According to the former, future potable water demands are forecasted in Figure 17 and expected expenditures are projected in Figure 18.

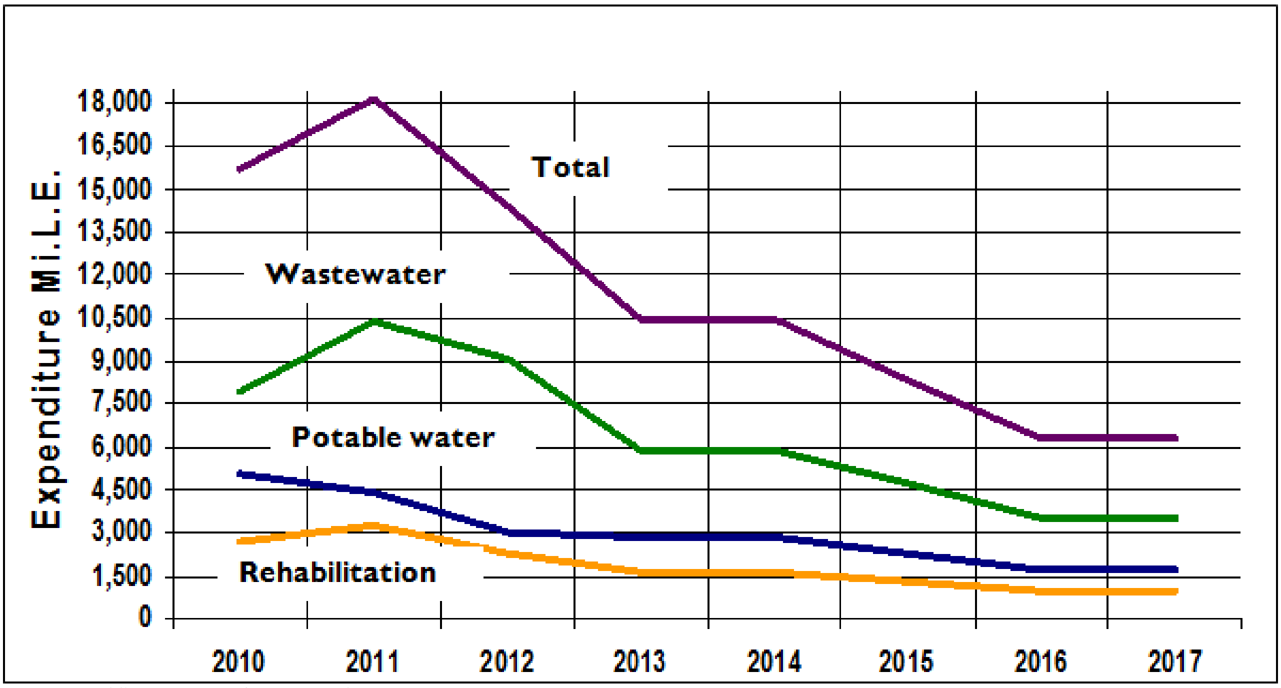
The rehabilitation program implemented by the company results in an average annual saving of 2% of concurrent losses. The per activity gains are significantly more than this figure, for example a total saving of 3000 CM/d, (22% of demand and 80% of losses) has been achieved in the district of Shobra alone upon implementation of the rehabilitation program. Further measures are continuously employed to reduce UFW through metering, electronic billing, and others.

Figure 17 - Forecasted Potable Water Demands and Wastewater Generation



Source: CEDARE, 2011

Figure 18 - Forecasted Expenditures in Water and Wastewater Sector



Source: Holding Company for water and waste water (2010)

2. Polices, strategies, and national targets

2.1. Irrigation Improvement Program

Water savings in agriculture are an important objective of Egypt's different sector strategies. The magnitude of potential water savings in agriculture and how best to achieve such savings, has been a subject of some debate following previous discussions. Water savings strategies in Egypt therefore should not focus only on water-saving irrigation technologies such as sprinkler or drip irrigation, but should be based on the observation that when farmers lack control of the timing and quantities of water supply, they irrigate too soon and apply too much water.

The feasibility of water savings in Egyptian agriculture was first assessed through pilot projects under the USAID-supported Egypt Water Use and Management Project (EWUP) (1977). The latter showed that in order to achieve water savings, it was important to:

- allow farmers to participate more in irrigation management through water user associations,
- provide continuous flow instead of rotational flow in branch canals,
- replace individual by collective pumping at tertiary levels, and
- create an irrigation advisory service.

The 1980 "Strategy for Irrigation Development in Egypt up to the year 2000" envisaged:

- the improvement of control and distribution of irrigation water, then
- the development of field irrigation systems and finally
- direct cost-of-service recovery for irrigation water

The national Irrigation Improvement Program (IIP) in 1985 has been implemented in eleven pilot areas, beginning with the Serri Canal with 120,000 feddans (50,400 hectares) in Minya Governorate. The project, with USAID support, has:

- replaced old low-lying Mesqas with raised Mesqas, from which water would flow to the fields via gravity.
- established 1,100 water user associations
- modernized systems irrigating 129,000 feddan
- reduced water losses, improved water quality at the tail end of mesqas, made more water available to farmers at the tail end of canals, reduced pumping costs by more than 50% and increased yields between 5% and 30%.

Building on this success the concept of farmer participation in irrigation management was extended to branch canals with the creation of Branch Canal Water Users Association beginning in 1997. From 1996 onwards the World Bank and Germany's development bank KfW supported the IIP with the ultimate objective to increase agricultural production and income. Achievements of this project include:

- establishing 2906 water user associations irrigating more than 200 thousand feddan (84,000 hectares) in the Western Delta (Mahmoudia) and the Northern Delta (Manaifa and Wasat).
- increasing net revenues only by 6-9% due to reduced pumping costs compared to a target of 30%, rated as "marginally satisfactory" by the World Bank in 2007.

The Integrated Irrigation Improvement and Management Project (IIIMP) is a seven years programs (2007), led by the world Bank, to directly address the issues of highest priority to Egypt's farmers such as the efficient use and management of water and land resources for agricultural production. It implements irrigation and drainage management improvement in about 230 thousand hectares representing 10% of the Nile delta, with full user's participation.

2.2. Mega projects

Three Mega-projects have been next initiated:

- The North Sinai Development Project includes the Al-Salam Canal, conveying re-used water, the initial purpose of reclaiming 220 thousand feddans west of the Suez Canal, of which 180 thousand feddan are already irrigated, in addition to 400 thousand feddans east of the Suez Canal.
- The New Valley Project (Toshka project) is fed from Lake Nasser through the Mubarak Pumping Station to irrigate 234,000 hectares in the Sahara. The project has begun in 1997, the pumping station has been completed in 2003 and the entire project is scheduled to be completed before 2020.
- The infrastructure Project for Irrigation Improvement in the West Delta Region to improve irrigation on 500 thousand feddan, reclamation of 170 thousand feddan and rehabilitation of infrastructure serving 250 thousand feddan. The latter to be implemented through a public-private partnership.

3. National Water Planning

Beginning in 1998 the Dutch government provided technical assistance to prepare a second national water plan to follow the 1981 Master plan and 1990 Water Resources Plan. The National Water Resources Plan (NWRP) was completed in 2003, launched in 2005, with a time horizon until 2017. The plan is based on four principles: to develop additional resources, make better use of existing resources, protect public health and the environment, and improve institutional arrangements. The plan includes both "vertical expansion" through more efficient water use and increased agricultural productivity and "horizontal expansion" by increasing the existing agricultural area of 7.8 million feddan (about 3.12 million ha) by an additional 1.4 million feddan (about 560 000 ha).[7] In June 2005 the Ministry presented an Integrated Water Resources Management Plan, which was prepared with technical assistance from the World Bank, as a "transitional strategy including further reform interventions building on the NWRP. The Plan includes 39 actions in the fields of institutional reform and strengthening, policies and legislation, physical interventions, capacity building, technological and information systems, water quality, economic and financial framework, research, raising awareness, monitoring and evaluation and transboundary cooperation. The physical interventions mentioned include irrigation improvement and rural sanitation.

The NWRP-CP project is launched by the Ministry of Water Resources and Irrigation, in 2009 to coordinate the implementation of the NWRP. The NWRP examined the situation in 1997 (the Base case) and two alternative scenarios for 2017, a “Business as Usual” (referred to as the Ref. case), and the recommended plan, Facing the Challenge (referred to as FtC). A summary of the impacts of these three cases on key sectors of the Egyptian economy is shown next.

[7] http://en.wikipedia.org/wiki/Water_resources_management_in_modern_Egypt#cite_note-FAO-3#cite_note-FAO-3

3.1. Impact of NWRP 2005

	Unit	1997 Base	2017 Ref	2017 FtC
General				
Population	Million	59.3	83.1	83.1
Urbanization	Ratio	0.44	0.48	0.48
GDP at economic growth of 6%	Billion LE	246	789	789
Economic development objectives				
Agriculture				
Irrigation area	M feddan	7.985	11.026	10.876
Gross production value	Billion LE	34.46	35.76	38.5
Crop intensity	Ratio	2.1	1.5	1.7
Net value production per feddan	LE/feddan	2,812	2,075	2,153
Net value production per unit of water	LE/m^3	0.64	0.66	0.6
Export/import value	Ratio	0.09	0.12	0.2
Industry				
Costs of polluted intake water	LE/m^3	0.65-1.10	0.65 -1.10	2
Wastewater treatment costs	LE/m^3	0.22- 0.50	0.22 -0.50	1
Fishery				
Production (index 100 in 1997)	Index	100	86	?
Tourism				
Navigation bottlenecks	Index	100	114	<100
Social objectives				
Create living space in desert areas	% of tot. pop	1.50%	23%	22%
Employment and income				
Employment in agriculture	M pers.year	5.01	6.24	7.3
Employment in industry	M pers.year	2.18	4.99	4.99
Average income farmers	LE/yr	5,362	4,629	4,309
Drinking water supply				
Coverage	Percentage	97.30%	100%	100%
Sanitation				
Coverage	Percentage	28%	60%	60%
Equity				
Equity water distribution in agriculture	-, 0, +	0	+	+
Self sufficiency in food				
Cereals	Percentage	73%	53%	46%
Meeting water needs				
Water resources development				
Available Nile water	BCM	55.5	55.5	55.5
Abstraction deep groundwater	BCM	0.71	3.96	3.96
Water use efficiency Nile system				
Outflow to sinks from Nile system	BCM	16.3	17.6	12.5
Overall water use efficiency Nile system	Percentage	70%	67%	77%
Water in agriculture				
Supply/demand ratio (1997 assumed 1.0)	Ratio	1	0.8	0.92
Water availability per feddan Nile system	m^3/feddan/yr	4,495	3,285	3,866
Public water supply				
UFW losses	Percentage	34%	34%	25%
Supply/demand ratio	Ratio	0.67	0.76	1
Health and environment				
Pollution and health				
E-coli standard violation (1997 = 100)	Index	100	121	110
Water quality shallow groundwater	-, 0, +	0	-	-
Ecology and sustainability				
Sustainability: use of deep groundwater	abstr/pot	0.15	1	1
Condition of Bardawil (Ramsar site)	-, 0, +	+	-	+
Condition of Coastal Lakes	-, 0, +	0	-	0

Source: National Water resources Plan 2017: Water for the Future, MWRI 2005, Page 5-43

3.2. Key Policy Issues as incorporated in NWRP (2005)

Policy initiatives / priorities	Indicators
Ministry of Agriculture and Land Reclamation	
1) Increase annual rate growth in the agricultural production to 4.1% annually and reclamation of 3.4 Million feddan up to 2017. 2) Initiating the implementation of national mega projects in new lands. 3) Efficient use and allocation of soil and water resources to increase productivity both horizontally and vertically. 4) Expanding the use of bio-technology for the development of high-yielding, early-maturing crop varieties. 5) Maximizing the benefit of comparative advantage in export promotion and to achieve food security	6) Total irrigated and cultivated area. 7) Crop intensity and productivity. 8) Net value production per unit of water. 9) Export/import ratio. 10) Self-sufficiency ratios of major crops. 11) Employment and average income of farmers.
Ministry of Housing	
12) Increase production capacity of drinking water to 23.3 million m^3/day in the year 2017 and coverage of 100% of population by drinking water. 13) Increase future capacity of wastewater treatment plants to 17 million m^3 /day in the year 2017. 14) Reduce wasteful use of drinking water in water networks and connections (water losses). 15) Restructuring of the organizations of the Utilities Sector to ensure better management. 16) Expansion in BOT projects in the Drinking Water Sector and promote privatization of new utilities projects.	17) Percentage coverage of drinking water networks and connections. 18) Percentage coverage of sanitary drainage services. 19) Drinking water supply/demand ratio 20) No. of water meters connected to households and users. 21) Unaccounted-for–Water losses (UFW) ratio. 22) Level of participation (e.g. investment) by the private sector.
Ministry of Industry	
23) Development and modernization of the Industrial Sector. 24) Establishment of new industrial database, management information system and the digital industrial maps. 25) Re-location of existing factories from the residential areas to new industrial cities to protect water resources and environment. 26) Protection of the Nile water from impacts of industrial wastewater (treatment facilities in 32 major industries) and recycling of industrial water.	27) Area of new industrial zones. 28) Current and future water consumption by industries. 29) Wastewater production by industrial activities. 30) No. of factories connected to treatment facilities.
Ministry of Environment	
31) Solid waste management 32) Nile pollution prevention by industries and other effluents 33) Safe use of treated domestic wastewater in forestation 34) Establishment of new environmentally-friendly industrial cities 35) Improving air quality 36) Environmental Impact Assessment (EIA) of projects 37) Sea shore and coastal environmental protection.	38) No. of safe solid waste disposal sites. 39) No. of industries established treatment facilities. 40) Area covered by wood forests. 41) No. of air quality measuring stations. 42) Compliance to the Law 4. 43) Coastal water quality (e.g. E-Coli)

Ministry of Health	
44) Protection of drinking water sources from pollution. 45) Secure suitable and good quality drinking water sources. 46) Continuous monitoring of surface water, treated water, effluent and groundwater quality. 47) Prevent water-borne diseases and protection of the public Health. 48) Safe disposal of solid and hazardous wastes.	49) Percentage of coverage of water supply network and public connections and sanitary drainage network. 50) Drinking water quality in canals (e.g. E-Coli, pathogens, heavy metals, etc.) 51) Drinking water quality in groundwater wells (e.g. iron and manganese, etc.)
Ministry of State for Local Development	
52) Co-ordination among all institutions related to development of local communities and local administration units in all governorates of Egypt. 53) Contribution in economic and social development plans in co-ordination with the governorates. 54) Identify the required programs and plans to improve services (e.g. drinking water, sanitation, electricity, roads, schools, health units and protection of environment) and establishment of database in information centers of villages. 55) Identify priorities for environmental protection projects in co-ordination with EEAA. 56) Coordinating and jointly funding communities-based programs, which involve services such as drinking water, sanitation, roads, education, health, etc.	57) Achievement of economic, social and environmental objectives and targets on local level. 58) Implementation of local (regional) action plans 59) Databases and information systems in villages and local areas. 60) Level of participation (e.g. investment) and contribution by local communities. 61) Level of improvement of various services.
Ministry of Transportation	
62) Delineation and improvement of navigational routes in the Nile and two branches. 63) Delineation of navigational route in the High Aswan Dam lake. 64) Maintenance of the navigational routes by dredging the shallow areas. 65) Rehabilitation and development of harbors on the Nile and two branches to receive large boats and ships and safe disposal of wastes by boats.	66) No. of boat trips per year. 67) No. of shallows in the Nile.
Ministry of Electricity	
68) Generation of electric energy from hydro-power stations at major barrages, at the Old Aswan Dam and the HAD. 69) Efficient use of cooling water and discharge with acceptable standards.	70) Water discharge rate, Average head, Efficiency, max load, maximum and minimum daily-generated energy. 71) Water quality of cooling water.
NGO's	
72) Rationalizing water consumption. 73) Avoiding disposing of solid waste and wastewater in the River Nile. 74) Acquiring safe and clean energy through use of organic substances resulting from animals and agricultural waste. 75) Consultation and co-ordination processes with the public and the governmental organizations.	76) Level of participation (e.g. investment) and contribution by donors and local communities. 77) Achievement of economic, social and environmental objectives and targets.

Source: CEDARE, 2011

4. Programs /projects adopted and possible water savings

The following list of water-related projects, based on various documents, as compiled by the NWRP-CP (2009).

- The Dutch-financed National Water Resources Planning Project (NWRP), which was carried out by the Ministry of Water Resources and Irrigation (MWRI) with support of the Government of the Netherlands. The main objective of NWRP is to describe how Egypt will safeguard its water resources in the future, both with respect to quantity and quality and how it will use these resources in the best way from a socio-economic point of view until the year 2017. NWRP considered all components of Egypt's water resources system, all functions and all water user sectors. By including the policy areas of other ministries, the plan was, in principle, 'owned' by all stakeholders involved. The resulting plan and policies were discussed and agreed by the inter-ministerial High Committee for Water Resources Management, chaired by the Minister of MWRI.
- The West Delta PPP Project in which the Government of Egypt, through MWRI reviewed several options for developing surface water for irrigation in the West Delta area that would minimize the depletion of the groundwater resource. In line with new sector policies, the Government is seeking to achieve full cost recovery and to identify practical ways for involving the private sector in the design, operation and even financing the delivery system for supplying surface irrigation water. Therefore, the project area (255,000 feddans) has been identified by the GOE in the West Delta for investment under this new philosophy of full cost recovery and Public-Private-Partnerships. The first phase comprises 95,000 feddans within area.
- The World Bank financed Integrated Sanitation and Sewerage Infrastructure Project (ISSIP) for three governorates in the Delta (Beheira, Kafr El Sheikh and Garbeya)
- EU – Water Sector Reform Programme (2005-2008) including Implementation of Integrated Water Management Policy comprises three tranches for a total of 80 million euro. The components are focused on: strengthening laws and by-laws; polluter pays principle; recovery of costs; public private partnership; water data; flow and discharge distribution control in old and new lands water networks of the Nile system management; impacts of reductions in drainage flows to the sea on Nile's dilution capacity; unlicensed cultivation of paddy and control of total cultivated area of rice. Support is also provided for water councils and technical secretariats in the NWRP and to finalize the legal basis for water quality management. In the mean time a new similar program is under design and approval.
- LIFE Integrated Water Resources Management Project (2003 – 2008, USAID) assisting with the decentralization of water management with important links to the Central Water Management Unit in the MWRI. The project provides assistance, training, commodities, and small grants to support decentralization of water management. The aim is to increase water efficiency and productivity through expanding decentralization. The first phase of the project will be completed by September 2008; the project has been extended for other 4 years to cover the second phase which will focus on integrated water resources management units and branch canal water users associations within the entire eastern Delta region.
- The National Water Quality and Availability Management Project NAWQAM (1997-2007) sponsored by the Canadian government aims to provide better knowledge of Egypt's water resources and to enhance the coordination and collaboration amongst the agencies and stakeholders having a direct interest in water resources.
- World Bank/MWRI Integrated Water Resources Management Plan, which is an alternative presentation of the NWRP using the language of IWRM to assess, inter alia, capacity, legal and institutional frameworks in Egypt. Broad aspects covered by the plan include water quality targeted as being 'fully controlled and monitored'. It assumes that water quality issues, plans and actions are executed at the hydrological level rather than governorate level, thus entirely excluding civil administration.

- The Nile Pollution Prevention Programme (NPPP) launched in July 1997 by the Ministry of State for Environmental Affairs (MSEA) to reduce industrial pollution to the Nile.
- Lake Nasser Flood and Drought Control Project (LNFDCP) which aims to study, assess and formulate strategies for the following aspects: Nile basin countries projects related to the water sector and development especially in the Eastern Nile. Climatic changes and its effect on the rain density and distribution in the Nile basin countries in addition to the economical and environmental effects which need to be assessed and put alternative solution for facing different scenarios.
- Irrigation Improvement and Management Project (IIMP) encouraging users' participation. The IIMP is a major project implemented in the old land to improve water management through rehabilitation and renewal of water distribution structure and encouraging Users' participation in O&M of the irrigation system.
- Integrated Irrigation Improvement Management Project (IIIMP) follow-up project including an integrated management plan combining quantity and quality. This is a follow-up project designed to achieve the following broad objectives: a) develop a framework for an integrated water management plan and program in selected command areas, combining water quantity and quality management through inter-agency and stakeholder consensus; b) improve institutional, financial and environmental sustainability of water services; and c) increase farm incomes through improved agricultural production based on efficient, more equitable and sustainable use and management of water and land resources. A key feature of IIIMP is to strengthen stakeholder involvement. The project builds on the outcome of other related projects including IIMP.
- The Dutch-financed Water Boards Project (WBP), which started in (1999-2003) and aimed to pilot on a national level the application of earlier experience in establishing water users organizations on secondary canals. The project developed a procedure for establishing and strengthening Water Boards and set up ten pilot Water Boards throughout Egypt. Two pilot District Water Boards were established through the Preparatory Activities Component (PAC) of IIIMP, which is providing support for the institutional aspects of the project. Formed and run by the users themselves, the Water Boards is expected to contribute to better water use efficiency, management and distribution.
- The Fayoum Water Management Project (FWMP) is an Egyptian-Netherlands development Cooperation program aimed at increasing the efficiency and equitable use of water in O&M. The goals are to enhance the structure and function of the local water boards, establish and test the concept of participatory integrated water management at district and directorate level. The project will continue through 2010.
- The Government of the Netherlands sponsored a project on Institutional Development and Organizational Strengthening. The program scope covered assessing the changing institutional environment of both MWRI and the Egyptian Public Authority for Drainage Projects EPADP. A project has also been commissioned by EPADP to design and supervise the production of a public awareness campaign to support MWRI in its effort to transfer responsibility of drainage organization and maintenance to farmers and other target groups. The assignment has been undertaken through a comprehensive participatory rapid appraisal PRA with all involved stakeholders, such as farmers, water users and EPADP staff, in four pilot areas. Since its creation in 1973, EPADP has been growing and adapting internally to respond to the task of implementing the world largest drainage construction program in a timely manner and in accordance to worldwide approved technical standards.
- The Second National Drainage Project, a World Bank supported project with a grant from the Japanese Government, aims at increasing agricultural productivity in Egypt through drainage improvement.
- Formation of an Action Programme for the Integrated Management of the Shared Nubian Aquifer (GEF/UNDP/IAEA 2005).
- Lake Manzala Engineered Wetland Project (GEF/UNDP).

Other donors' funded projects include: a) Decision Support System DSS based on environmental balance (1998-2000) funded by the Italian government, b)Water Resources Result Package, Environmental Policy and Institutional Strengthening Identified Quality Contract (EPIQ-WRRP) (1997-2002) funded by USAID, c) Monitoring, Forecasting and Sustainable Project (1999-2002) funded by USAID, and d) Groundwater Resources for Egypt (GWR) funded by the Dutch government.

In addition to the above technical assistance projects for Egypt, several donors' funds have been included in the recent Nile Basin Initiative (NBI). The combined budget of these projects is 108 million US Dollars. The projects include:

- Nile Trans-boundary Environmental Action (GEF, Canada and The Netherlands)
- Efficient Water Use for Agricultural Production (Norway, Sweden, Finland, Denmark)
- Water Resources Planning and Management (Denmark, UK, Germany, Norway, GEF

IV. Economic approach to water management[8]

In general, improving the water management status in any country, while adopting a sole economic approach, has two pre-requisites. The first requires establishing clear property rights for water while the second demands the creation of more efficient markets for water. Efficiency (from an economic point of view9) implies treating water as an economic resource, with prices based on supply and demand rather than subsidized administered prices or no price at all, Doss (2002). Proper pricing of water should allow market forces to operate and provide a stronger financial incentive for people to conserve water, which would then address emerging supply problems. A market for water also means that human behaviour and demand are driven by opportunity cost. Various economic incentives can also play a significant role in reducing water pollution, which in turn would help address supply deficits. Furthermore, improving participatory efforts to manage water resources and strengthen coordination between sectors, local government, and institutions.

In Egypt limited water resources has a major impact on agriculture output, along with adverse water quality impacts associated with excessive reuse (to account for nearly one quarter of the water used for agriculture) in addition to loss of old agricultural land due to urban encroachment. These problems undermine the prospects of expanding agriculture output from lands presently under production. Fragmented land ownership along with fragmented institutional setup of key actors within the water sector adds another challenge to correct economic evaluation since each of the previous factors will have to contribute to the estimate for the economic efficiency. One solution has been the initiation of Mega projects such as Toshka project in the south and Al Salam canal project (transporting reused water) to Sinai. It has been initially assumed (2000) that the new cropped area will grow by 1.5% providing 14% of the increased production, pending increasing application and conveyance efficiencies to 80%.

On the other hand, pricing perspectives imply that the value of water to the user is the highest amount the user would be willing to pay for the use of the resource and reversibly, the price will dictate the rate of use. This directly results into either increased efficiency of water use, or farmers can leave land uncultivated, implying that some farmers will leave the sector, Doss (2001). Counterargument against market prices for water is that farmers cannot afford higher input costs because of below-world market farm-gate prices presently received for production. Thus it is argued that if farmers pay for irrigation water directly, the price should be below market levels to offset the low prices received for production. At the same time however, farmers would still have to rationalize operations either by increasing productivity, growing higher valued crops, using water more efficiently, or striving to meet all three objectives simultaneously.

Allocating water use among sectors or among crops is another challenge. One approach for policy-makers is to compare the change in Gross Domestic Product (GDP) per unit of water use in sectors. This will lead to a preference for allocation to the service sector followed by the industrial sector and least will be the agricultural sector which is preceded by twenty folds in favour of industry. However, such approach may be misleading as it masks the inputs of the former to the latter; for example agricultural inputs in relation to agro industries. It also assumes that water allocations in one sector will be cost-free to other sectors.

Another approach assumes that water could be allocated to the sector where the benefits out-weigh the costs of reduced availability in the other sectors. In this case, switching water to services from agriculture may not be optimal when costs are accounted for. Estimates will differ if the efficiency of water use is increased, for example using more efficient application systems such as sprinkler or drip systems with laser land levelling. This also applies to water allocations between old and new lands and between different cropping patterns. Further, since recycling is an important element of water supply in Egypt, it is critical that pollution is reduced from agricultural, industrial and domestic sources. This would allow a greater volume of water to be used more than once before it reaches the sea. Economic incentives have a strong role to play in addressing water pollution. A major conclusion from applying the previous concepts to arrive at an optimal allocation by Doss (2001) has been that implementation of solutions must be on a case-by-case

[8] The material presented under this chapter represents various attempts, already existing, to address the economic approach. Further details of water sector expenditure analysis are referred to other sources like the World Bank Water Sector Review of Egypt (2004)
[9] Which is not explicitly acceptable in Egypt

study in-order to find the true cost to the society to encourage or discourage particular uses, thus creating incentives for individuals to operate in the common good.

1. The Integrated Irrigation Improvement and Management Project (IIIMP)

Integrated Irrigation Improvement and Management Project (IIIMP) directly addresses the issues of highest priority to Egypt's farmers such as the efficient use and management of water and land resources for agricultural production. More participatory planning and decision-making is developing substantially under the project through the creation of branch canal and tertiary level water user associations, WUAs as well as district water boards, DWBs. The project implements an integrated management approach and with user's involvement key issues for irrigation and drainage management improvements in two full canal command areas in the Nile Delta, covering a gross area of 230,000 ha; about 10% of the total irrigated area in the Nile Delta or 6.5% of the total irrigated area in Egypt.

A detailed project implementation plan has already been developed to outline the project structure within the involved agencies along with the role and responsibility of every involved institution. This covers implementation arrangements for water management system and land productivity improvements, institutional developments and environmental mainstreaming.

Using the with- and without-project methodology, Economic Rate of Return (ERR) and Net Present Value (NPV) were estimated for the new integrated water management approach under the IIIMP. Water savings are expected to reach about 22% or 838 million m^3 per year at project maturity. Assigning no economic value for the water saved, the project would have an ERR of 20.5%. The NPV at a discount rate of 12% was estimated at about US$141 million. If water is assigned an economic value equivalent to the residual imputed economic value derived from the without-project situation (US$ 0.08/m^3), which could be considered today's opportunity cost of water, the ERR of the project would be 30.4% and the NPV would be US$379 million.

Furthermore, the following figures are of direct relevance to agricultural economic analysis in Egypt. Average cost of irrigation development is about US$800/ha for localized irrigation of orchards and about US$1,200/ha for localized irrigation of vegetable or field crops. Mobile sprinkler irrigation costs about US$800/ha and stationary sprinkler irrigation costs about US$1,800/ha.

2. The National Water Resources Plan (NWRP)

The total investments needed by the national plan to apply its measures amount to LE145 billion for the period 2003–17 (NWRP, 2005). The major shares in this investment are taken up by the Ministry of Housing, Utilities and New Communities (62%), the Ministry of Water Resources and Irrigation (32%) and other related ministries (1%). The private sector share is 5% of these investments. The total recurrent costs in the same period 2003–07 are LE41 billion. These costs include the O&M costs of the system but exclude the personnel costs. The municipalities percentage of the O&M of the drinking water and wastewater treatment plants is 70%. The MWRI will cover 12% while the private sector will cover 15%. Other related ministries of Agriculture, Health and Environment will cover 3%.

The NWRP-CP (2009) argues that applying IWRM to canals, drains and other components is not enough to ensure that economic growth continues and vulnerability is limited. It is vital to adopt a "Water In the National Economy (WINE)" approach, a term used to describe the truly inter-sectoral approach in the NWRP that encompasses issues of family planning, international food trade and job-creation through industrial growth, all of which affect Egypt's ability to develop its economy despite the constraints of water availability. The major issues to be addressed under the WINE approach may be summarized as follows:

Securing water for people: Access to safe drinking water is the first requirement that has to be met. The top priority is to provide adequate drinking water of a quality that complies with health standards and to do this, the necessary facilities such as drinking water plants and distribution systems must be constructed and operated properly.

Securing water for industry, services and employment. Egypt will have to give priority to the development of livelihoods based on industrial and services sectors rather than traditional agriculture. Although in general the quality needed for industry is lower than that needed for human consumption, treatment is usually required.

Securing water for food production. The horizontal expansion plans of the Government will increase the demand for irrigation water. Since municipal and industrial demands are growing, and are assigned great priority, the total water available to the agricultural sector is falling. Hard choices will have to be made about how much irrigation water can be reassigned from existing farmers on the old lands to new farmers on the new lands. Given the proportion of the population dependent on agriculture, the impact of expansion on farmer incomes is a factor that cannot be overlooked.

Managing leakage losses, sewage and effluent treatment. Domestic, municipal and industrial sectors have an obligation to limit their demands and ensure that flows returned to the system do not pollute the water supply of downstream users. It is vital to both reduce distribution losses and improve sewage treatment in order to maintain the maximum possible supply of clean water to downstream users.

Developing a solid institutional framework. The concept of WINE calls for cooperation between stakeholders, decentralization and private sector participation. This requires more than the IWRM concept of cooperation among water users sharing the flows in a river basin. It calls for a coordinated approach to policy making, implementation and management across sectoral, institutional and professional boundaries. It also requires that the institutions involved have sufficient legal and financial means to carry out their tasks, and the will to act collaboratively.

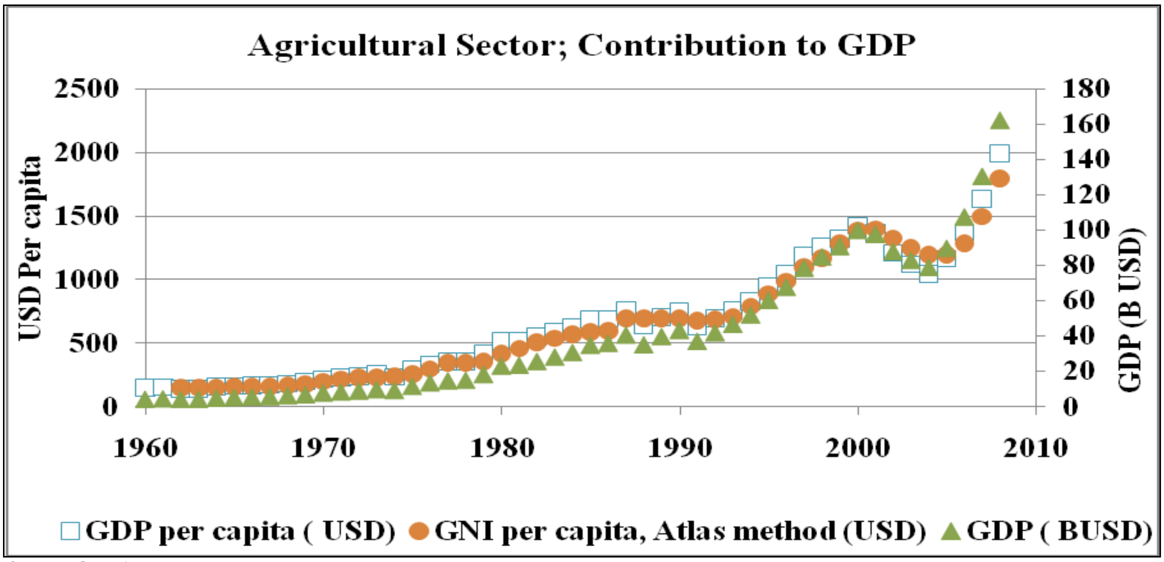
Protecting and restoring vital ecosystems. The aquatic ecosystems in Egypt have to be protected against deteriorating quality of the water, with serious consequences for the quality of the freshwater fish that are an important source of protein for many Egyptians.

Stimulating the political will to act. Bringing water resources issues to the top of the political agenda is fundamental to the long-term success of sustainable water resources management. Political attention and support is an essential condition to ensure good decision making and the necessary investments in the development of the water resources in Egypt.

Co-operating with Nile Basin countries. Early in 2009, Sudan officially opened the Merowe dam, one of several that are likely to be built in the coming decades throughout the Nile basin. Even if such dams are built only for hydropower, reservoir filling and evaporative losses may impact water availability. Continued cooperation with other Nile riparian's is vital to protect Nile flows to the maximum possible extent.

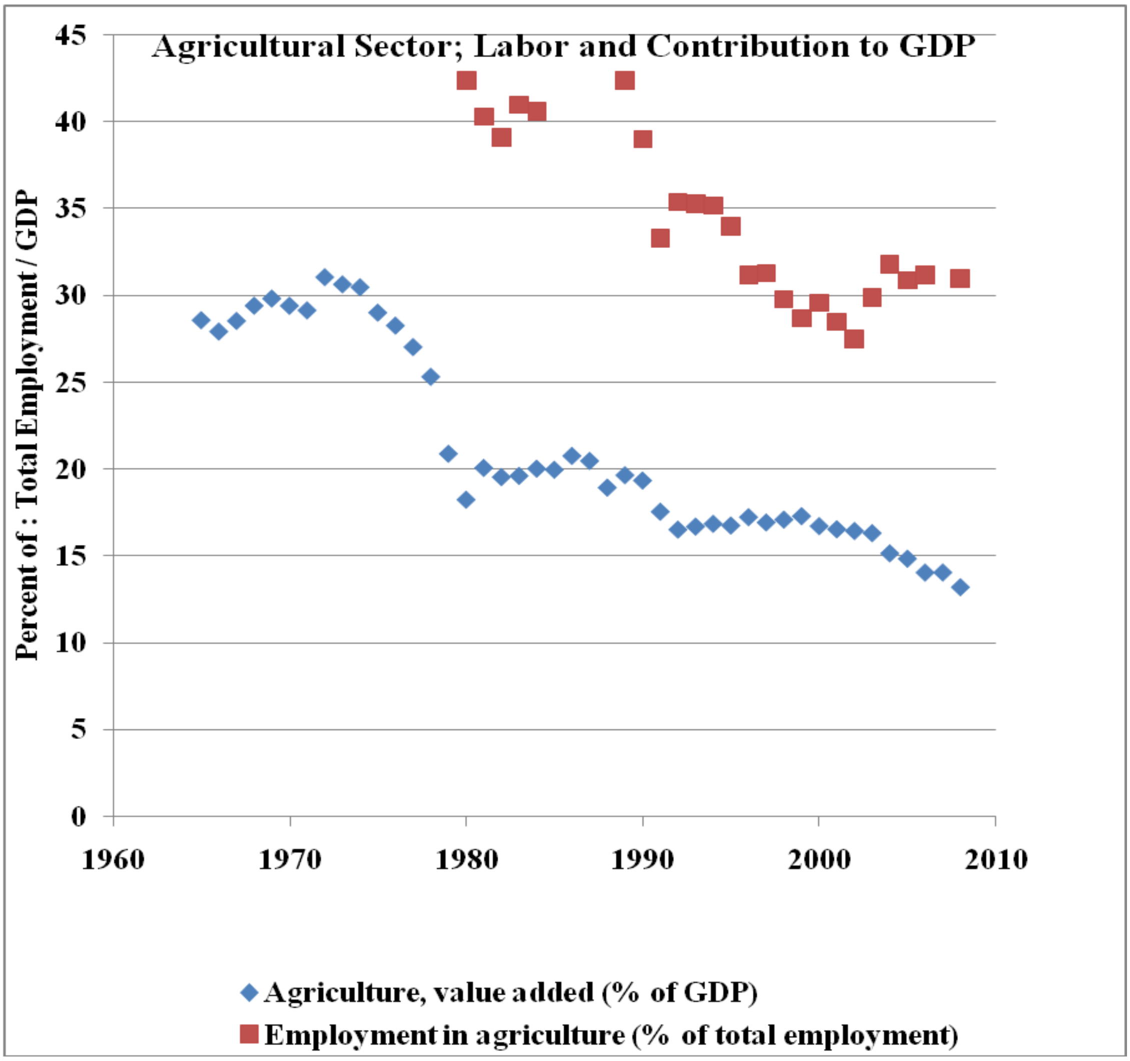
Following figures (19 & 20), the agriculture's share of the GDP fell from 34.3 % in 1955 to 16.7% in 2000, while its share of employment fell from 56% to 29.6 % over the same period (World Bank, 2004). Nevertheless, agriculture remains the most important sector of the Egyptian socioeconomic structure as envisioned from the labour force distribution.

Figure 19 - GDP of Egypt over Fifty Years



Source: CEDARE, 2011

Figure 20 - Contribution of Agricultural sector to GDP and to labour force



Source: CEDARE, 2011

Egypt has a number of practical field methods, by which water loss can be reduced and water use efficiency increased, for example lining the irrigation-feeder-canals (reduces the rate of seepage), using closed conduit conveyors instead of open canals (reduces evaporation), and land preparation and exact levelling of the irrigated areas, possibly with a slight slope. NWRP measures for increasing water use efficiencies are summed in Table (5). Expenditures corresponding to different measures are expanded in Table (6).

Table 5 - NWRP Measures for increasing water use efficiency

No	Measures on MORE EFFICIENT USE	Criteria				Score
		Effectiveness	Efficiency	Legitimacy	Sustainability	
	AGRICULTURE					
	Institutional and cost recovery					
113	Train MWRI and Water Board staff in system operation	++	++	+	+	6
33	Transfer water management authority to Water Boards	+	++	+	+	5
69	Continue the set- up of Water Users Associations	+	++	+	+	5
71	Strengthen Irrigation Advisory Service	+	++	+	+	5
100	Implement systems of cost sharing for all water users	++	+	O	+	4
21-23	Set import duties to affect self - sufficiency of various commodities	+	0	+	+	3
24	Introduce crop- based cost recovery	O	+	O	+	2
	Horizontal expansion					
123	Make hor. expansion dependent on availability of new water res.	++	++	O	++	6
95	Continue horizontal expansion	+	+	+	+	4
112	Postpone Middle Sinai developments	+	+	+	+	4
118	Enforce reduction of loss of agricultural land	++	+	O	+	4
	Improvement overall water use efficiency					
57	Introduce controlled drainage for rice cultivation	+	++	+	+	5
78	Apply modern irrigation techniques in new areas	++	+	+	+	5
97	Promote cultivation of salt tolerant crop varieties in the Delta	+	++	+	+	5
114	Allow higher permissible salinities of irrigation water	+	++	+	+	5
36	Apply land levelling with laser techniques	+	+	+	+	4
50	Improve drainage conditions in old lands	++	+	O	+	4
51	Apply intermediate reuse of drainage water at appropriate locations	+	+	+	+	4
82	Gradually introduce modern irrigation techniques in oases	++	+	O	+	4
86	Apply canal lining in effectives stretches	+	+	+	+	4
90	Continue IIP activities in prioritised areas	++	+	O	+	4
115	Prioritise drainage water reuse in selected areas	+	+	+	+	4
124	Prioritise efficiency measures in effective areas	++	+	O	+	4
56	Reuse treated waste water in New Industrial and Canal Cities	+	+	O	+	3
63	Restrict rice cultivation	+	+	O	+	3
39	Reduce evaporation losses from fallow lands	-	O	++	++	3
83	Transfer drainage water from Middle Delta to Eastern Delta	+	+	O	+	3
81	Apply conjunctive use of surface and groundwater	+	++	-	-	1
	Water allocation and distribution					
111	Establish MALR/MWRI coordination mechnism on supply&demand	++	++	+	+	6
68	Improve physical infrastructure for water distribution	+	++	+	+	5
104	Introduce deficit irrigation	+	++	+	+	5
99	Control well discharges in desert areas	+	+	+	+	4
122	Reduce irrigation supply after rainfall	+	+	O	++	4
93	Introduce regional water allocation based on equal opportunities	+	+	O	+	3
98	Introduce water allocation based on fixed annual amounts per feddan	+	+	O	+	3
116	Introduce water delivery agreements between MWRI and WBs	+	+	O	+	3
72	Provide WUAs with continuous water supply	O	O	+	+	2
	Demand management and maintenance					
6	Provide solid waste collection and disposal systems in rural areas	++	++	+	+	6
46	Extend aquatic weed control by grass crap	+	++	+	+	5
52	Tax high water consuming crops	O	+	O	+	2
59	Introduce tradable water rights	+	+	-	+	2
53	Subsidise low water consuming crops	O	O	O	+	1
	Research					
34	Study different operation of High Aswan Dam	+	++	+	+	5
44	Develop salt tolerant crop varieties	+	++	+	+	5
62	Develop short duration and drought resistant crop varieties	+	++	+	+	5
45	Enhance research on solar desalination for agriculture	+	-	+	+	2
	MUNICIPAL AND INDUSTRIAL					
11	Increase drinking water treatment capacity	++	++	++	+	7
18	Install / rehabilitate municipal water metering & control	++	+	+	+	5
19	Review price policy of drinking water	+	++	+	+	5
49	Increase brackish/salt water desalination	+	++	+	+	5
43	Intensify water conservation awareness campaigns	+	+	+	+	4
87	Reduce leakage losses in PWS systems by prioritisation	+	O	+	+	3
54	Promote water saving technologies in industries	+	O	O	+	2
47	Use aquifer for storing of treated waste water	+	O	O	O	1

Source: CEDARE, 2011

Table 6 - Investments Associated with NWRP Measures

No.		Agency	Total cos	2003	2004	2005	2006	2007	2007-12
	Developing additional resources		**8 274**	**350**	**537**	**579**	**612**	**613**	**2 961**
	Nile water		**2 533**	**34**	**222**	**218**	**223**	**224**	**975**
120	Continue the co-operation with the riparian states of the River Nile	MWRI	2 533	34	222	218	223	224	975
	Groundwater		**4 311**	**287**	**287**	**292**	**287**	**287**	**1 436**
35	Groundwater development Western Desert	MWRI	3 500	233	233	233	233	233	1 167
119	Groundwater development Sinai and Eastern Desert	MWRI	807	54	54	54	54	54	269
37	Development brackish groundwater for agriculture and aquaculture	MWRI/MALR	4.4			4.4			
121	Increase management of shallow groundwater	MWRI	0						
	Rainfall and flash flood harvesting		**631**	**28**	**28**	**38**	**38**	**38**	**230**
40	Stimulate rainfall harvesting along Northern Coast	MWRI	100	8	8	8	8	8	30
48	Stimulate on-farm rainfall harvesting along Northern Coast	MALR		0	0	0	0	0	0
41	Flash flood harvesting in Sinai and Eastern Desert	MWRI	531	20	20	30	30	30	200
	Desalination		800	**0**	**0**	**32**	**64**	**64**	**320**
49	Increase brackish / salt water desalination	Private/MWRI	800			32	64	64	320
	Making better use of existing resources		**41 512**	**2 819**	**3 709**	**3 622**	**3 326**	**3 317**	**13 098**
	Horizontal expansion		**7 750**	**601**	**701**	**602**	**305**	**305**	**2 618**
112	Postpone Middle Sinai developments	MWRI	0						
123	Make future horizontal expansion dependent on water availability	MWRI/MALR	0						
95	Continue horizontal expansion	MWRI/MALR	7 750	601	701	602	305	305	2 618
	Water use efficiency Nile system - irrigation efficiency		**10 196**	**422**	**1 087**	**1 088**	**1 088**	**1 088**	**3 040**
124	Prioritise efficiency measures in effective areas	MWRI	0						
90	Continue IIP in prioritised areas/IIMP	MWRI	6 700	400	450	450	450	450	2 250
71	Strengthen Irrigation Advisory Service	MWRI	0						
86	Apply canal lining in effective stretches	MWRI	335	22.3	22.3	22.3	22.3	22.3	111.5
36	Apply land-leveling with laser techniques	MALR	0						
57	Introduce controlled drainage during rice cultivation	MWRI/MALR	16			1	1	1	6
78	Apply modern irrigation techniques in new areas	Private	3 003		601	601	601	601	601
82	Gradually introduce modern irrigation techniques in oases	MWRI/MALR	143		14	14	14	14	71
99	Control well discharges in desert areas	MWRI	0						
122	Reduce irrigation after rainfall	MWRI	0						
	Water use efficiency Nile system - reuse of drainage water		**3 998**	**335**	**336**	**336**	**336**	**336**	**1 460**
50	Improve drainage conditions(EPADP)	MWRI	**3 833**	326.6	326.6	326.6	326.6	326.6	1400.0
	Review drainage water reuse policy, including		0						
51	- Apply intermediate reuse at appropriate locations	MWRI	63	4.2	4.2	4.2	4.2	4.2	21.0
115	- Prioritise drainage reuse in specific areas	MWRI/MALR	0.0						
114	- Allow higher permissible salinities in irrigation water	MWRI/MALR	94.2	4.1	4.3	4.5	4.5	4.5	36.2
97	Promote cultivation of salt tolerant crop varieties	MALR	7.5	0.5	0.5	0.5	0.5	0.5	2.5
	Water allocation and distribution Nile system		**18 158**	**1 359.5**	**1 483.8**	**1 497.8**	**1 502.8**	**1 493.8**	**5 517.2**
33	Transfer water management authority to Water Boards at District level	MWRI	See under General institutional, legal and financial measures						
69	Continue set-up of Water Users Associations at mesqa level	MWRI	0						
93	Introduce regional water allocation based on equal opportunities	MWRI	0						
98	Introduce water allocation based on fixed annual amounts per feddan	MWRI	90.20	8.20	5.50	5.50	5.50	5.50	30.00
67	Continue canals and drains dredging and de-weeding	MWRI	2 100.00	140.00	140.00	140.00	140.00	140.00	700.00
68	Improve physical infrastucture for proper water distribution	MWRI	183.00	12.2	12.2	12.2	12.2	12.2	61.0
111	Establish MALR/MWRI coordination mechanism on supply and demand	MWRI/MALR	0.45	0.03	0.03	0.03	0.03	0.03	0.15
116	Introduce water delivery agreements between MWRI and Water Boards	MWRI	0						
113	Train MWRI and WB-staff in system operation	MWRI	1	0.05	0.05	0.05	0.05	0.05	0.25
32	Rehabilitate barrages and regulators	MWRI	2 225	276	403	417	422	413	254
42	Rehabilitate and further develop pumping stations in river and canal system.	MWRI	10 021	668	668	668	668	668	3 340
38	Maintain and improve High Aswan Dam and Lake Nasser	MWRI	1 765	117.7	117.7	117.7	117.7	117.7	588.3
61,91	Continue works on River banks, Sea Shores and Mapping	MWRI	1 630	128	128	128	128	128	496
6	Provide solid waste collection and disposal systems in rural areas	Municipal.	0						
46	Extend aquatic weed control by grass carp in addition to the mechanical control	MWRI/MALR	142.5	9.5	9.5	9.5	9.5	9.5	47.5
	Municipal and industrial water (quantity)		**367**	**25.6**	**23.9**	**24.9**	**24.9**	**24.9**	**122.3**
18	Install/rehabilitate metering system	Municipal.	249	17.3	17.3	17.3	17.3	17.3	82.1
19	Review price policy of drinking water	Municipal.	1.00	0.10	0.10	0.10	0.10	0.10	0.25
43	Intensify water shortage awareness campaigns	MWRI	90	8.2	5.5	5.5	5.5	5.5	30.0
54	Promote water saving technologies in industry through Campaigns	MoI/MWRI	27	0.0	1.0	2.0	2.0	2.0	10.0
87	Reduce leakage losses in PWS system by prioritisation	MHUNC/Municp.	0						
56	Reuse treated wastewater in New Industrial and Canal Cities	NOPW./MALR/MWRI	0.036	0.000	0.001	0.005	0.010	0.010	0.010
	Aquaculture		**1.26**	**0.00**	**1.26**	**0.00**	**0.00**	**0.00**	**0.00**
75	Review MWRI policies regarding aquaculture	MWRI/GAFRD	1.26		1.26				
	Navigation		**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**
60	Remove shallows in Nile and canals through dredging	MWRI	0.00						
	Research		**1041.65**	**75.84**	**75.84**	**73.13**	**68.72**	**68.72**	**340.68**
34	Study different operation of High Aswan Dam	MWRI	16.18	8.09	8.09				
96	Continue activities of the National Water Research Center	MWRI	799	53.2	53.2	53.2	53.2	53.2	266.2
129	Conduct family planning awareness campaigns	MOHP	203	13.5	13.5	13.5	13.5	13.5	67.5
44	Develop salt tolerant crop varieties	MALR	8	0.5	0.5	0.5	0.5	0.5	2.5
62	Develop short duration and drought resistant crop varieties	MALR	8	0.5	0.5	0.5	0.5	0.5	2.5
37	Use of brackish groundwater for agri/aquaculture	MWRI/MALR	9			5.4	1.0	1.0	1.9

No.		Agency	Total cost	2003	2004	2005	2006	2007	2007-12
	Protection of public health and environment		**95 031**	**8 808**	**8 812**	**8 827**	**8 823**	**8 823**	**30 367**
	Prevention		**939**	**67**	**70**	**70**	**67**	**67**	**300**
4	Introduce financial incentives to promote clean industrial products	MoI	900	60	60	60	60	60	300
80	Start public disclosure pollution control program for industries	EEEA	0						
101	Introduce compliance action agreements for industries	EEAA	0						
3	Initiate public awareness campaigns for clean products	EEAA	6		3	3			
17	Phase out and relocate polluting industries along vital waters	MoI	0						
9	Introduce load based discharge levies	MWRI	0						
13	Encourage use of environmentally friendly agricultural methods	MALR	33	7	7	7	7	7	
31	Control the production and import of agrochemicals	MALR	0						
135	Control the use of organic fertilisers	MALR	0						
	Treatment		**93 736**	**8 706**	**8 706**	**8 706**	**8 706**	**8 706**	**30 001**
10	Increase municipal sewerage and waste water treatment	MHUNC./Mun.	61 765	5 412	5 412	5 412	5 412	5 412	22 000
11	Increase drinking water treatment capacities	MHUNC./Mun.	28 250	2 750	2 750	2 750	2 750	2 750	7 500
108	Initiate cost recovery for urban sanitary services	MHUNC/NOPW.	1.50	0.10	0.10	0.10	0.10	0.10	0.50
103	Start local action plans on domestic sanitation in rural areas	MoLocalDev.	1 500.00	100.00	100.00	100.00	100.00	100.00	500.00
127	Encourage treatment or pre-treatment of industrial waste water by industries	MoI/EEAA	0.00						
102	Collect and/or pre-treat industrial waste water separately	EEAA	2 220	443.97	443.97	443.97	443.97	443.97	
	Control		**160.75**	**22.70**	**22.90**	**38.68**	**37.73**	**37.73**	**1.00**
89	Define functions of waterways	MWRI	0.95			0.95			
29	Define effluent standards based on the receiving water	MWRI/MOHP	0.00						
7	Include reduction of human contact with polluted water in local action plans	MoLocalDev.	0.00						
2	Divert pollution away from Northern Lakes	MWRI	43.30			14.43	14.43	14.43	
79	Protect groundwater wells from pollution	MoLD/MHUNC	4.00	0.20	0.40	0.80	0.80	0.80	1.00
1	Select proper sources for public water supply	MHUNC/MWRI/MHOP	37.50	7.50	7.50	7.50	7.50	7.50	
8	Provide sewage disposal systems in unconnected areas	MHUNC(NOP.)	75.00	15.00	15.00	15.00	15.00	15.00	
	Institutional actions for water quality and public health		**195.00**	**13.00**	**13.00**	**13.00**	**13.00**	**13.00**	**65.00**
117	Enhance water quality monitoring and information dissemination	MOHP/EEAA	195.00	13.00	13.00	13.00	13.00	13.00	65.00
128	Train MWRI and WB staff on pollution and water quality	MWRI	0.00						
107	Strengthen institutions controlling and monitoring industrial pollution	EEEA	0.00						
	General institutional, legal and financial measures		**244.60**	**7.30**	**20.15**	**20.15**	**16.35**	**16.15**	**82.25**
106	Restructure the role of MWRI - establish dedicated IRU	MWRI	53.90	6.30	6.30	6.30	2.50	2.50	15.00
109	Co-ordinate investments on regional and national levels	MWRI	7.00	0.00	0.50	0.50	0.50	0.50	2.50
130	Restructure MWRI - establish integrated water management districts	MWRI	140.00		10.00	10.00	10.00	10.00	50.00
33	Transfer water management authority to Water Boards at District level	Cabinet/MWRI	22.40		1.60	1.60	1.60	1.60	8.00
20	Stimulate Private Sector Participation in infrastructure and O&M	MWRI	5.25	0.25	0.50	0.50	0.50	0.50	1.50
100	Implement systems of cost sharing for all water users	MWRI	4.80		0.50	0.50	0.50	0.30	1.50
131	Continue water sector planning as a rolling exercise	MWRI	3.00	0.20	0.20	0.20	0.20	0.20	1.00
132	Enhance the data exchange among different authorities	All Gov. Org.	3.00	0.20	0.20	0.20	0.20	0.20	1.00
94	Establish a permanent inter-minsterial Commission on IWRM	Cabinet/MWRI	3.75	0.25	0.25	0.25	0.25	0.25	1.25
133	Enhance role of NGO's and Civil Society	MWRI/Private	1.50	0.10	0.10	0.10	0.10	0.10	0.50
90	**Overall Total**		**145 063**	**11 984**	**13 078**	**13 049**	**12 777**	**12 770**	**46 508**

Source: CEDARE, 2011

3. Alternative water saving options

Apart from the NWRP measures, several water saving approaches may be implemented. Two tested examples include improved ETo-oriented geographical distribution of crops, and scheduling of irrigation using Daily Data Based Model.

A better geographical distribution of crop types would seem much more sensible: crops with lower water requirements should be grown in areas with higher reference ETo, and vice versa. Hokam estimates a saving of 250 m^3 /feddan when such considerations are implemented (following experiments in Ismailia, Port Said and El-Arish).

Limiting rice cultivation to the extent required for stabilizing the saltwater –freshwater interface beneath the delta (around 420,000 ha), and reducing the area under sugar cane cultivation.

In the planning of irrigation management, many agronomists calculate the necessary parameters (plant water requirement, ETc, allowable soil-moisture depletion, P, and root-depth of plants, Zr) using average values. Should these be replaced with daily (or weekly) values to reflect climate variations, a saving of 550 m^3/ha (about 230m^3/feddan) may be achieved, Hokam (2002).

4. Water savings between reality and illusion

A highly ambitious program has been set by the Ministry of Agriculture and Land Reclamation (MALR) to achieve a potential saving of 13 BCM/y (about 35% of current agricultural demand) and applying this water saving in expanding existing arable lands. Potential savings are envisioned through:

- Replacing traditional surface irrigation with modern irrigation (sprinkler and drip)
- Reducing conveyance losses through replacing open conduits with closed conduits!
- Selection of cropping patterns, which are less water consumptive and/or has a high water return value.

The main highlights of the proposed program are summarized as:

1) Improving the current irrigation efficiency from its current value to 80%[10]
2) Increasing arable land by 10% (previously occupied by open irrigation conduits)[11]
3) Water savings (13 BCM/y) may contribute to additional arable lands between 3.1 to 3.7 million feddans at no additional water demands
4) Crop productivity and economic return increases by 15%
5) Estimated costs for applying the program to 5 million feddans of old lands = 30 B.L.E.
6) Estimated costs for reclamation of 3.2 million feddans of new lands = 120 BCM
7) Total expected expenditures = 151.5 B.L.E.
8) Assuming a base return value of 4000 L.E./Feddan, expected return corresponding to 15% enhancement in productivity = 3 B.L.E./yr
9) Revenue for newly reclaimed 3.2 million Feddans = 13 B.L.E.
10) Annual expected revenue = 18 B.L.E.
11) Additional benefits of job g=creation, energy savings, and enhancing water quality

While the program seems to provide a prosperous future, it is unfortunately too good to be true. Basic assumptions of achieving 13 MCM/yr of water savings due to enhanced conveyance and field efficiencies is far from reality for the reasons discussed under section 2 of this report, not to mention the expected social tensions and restlessness at the old lands. A maximum saving of 3 BCM/y seems more realistic, and can be achieved through surface irrigation improvement in old lands. This conservative figure is more realistic as there is already dependence on reuse of groundwater recharge seeping through the irrigation networks, and reuse of agriculture drainage water resulting from excessive irrigation by some users especially upstream. Achieving this conservative water savings figures requires tedious interventions though and firm policies. Should that be the case, policy makers are advised to consider the creation of the same water savings (3 BCM/y), at less than 15% of proposed expenditures, through the implementation of previously proven programs such as the IIIMP. The initiation of a program for wastewater treatment (already planned and designed, and awaiting funding) would also add to the water needed especially for agriculture in the near future (AbuZeid, K., 2009). Additional benefits would be to ameliorate portion of the excessive pollution pressure exerted on land and water resources.

[10] At the same time the document assumes a targeted overall efficiency of 75% for improved surface irrigation (land leveling, closed conduits, gated outlets)
[11] Which is hard to achieve with fragmented land ownership, not to mention the expected frequent blockage of underlying closed conduits.

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