SAFE WASTEWATER USE IN AGRICUTURE IN EGYPT: CASE STUDY

By
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1. INTRODUCTION

Fresh water is a finite, vulnerable and vital resource, which has social, economic and environmental implications. Today, however, the widespread scarcity, gradual destruction and increasing pollution of fresh water resources in many world regions, along with progressive encroachment of incompatible activities leads to aggravating the problem. The major dilemma the world faces is how to increase and sustain productivity of irrigated agriculture while reducing the sector's water consumption. In other words, the challenge will be to produce more food with less water.

The countries of the Middle East and North Africa region have 5% of the world's population but have less than 1% of the world's renewable fresh water. The region is the driest in the world and poorly endowed with natural freshwater supplies. The easily accessible water resources, surface and groundwater, of good quality have now been almost entirely committed.

Egypt in the world of scarcity is not an exception. The present per capita availability of water is approximately 985 m^3/yr today, while the per capita availability of cultivated land is as low as 0.12 acre. The main and almost exclusive source of water for Egypt is the Nile River, which represents 97% of the country's fresh water resources. The river supplies water to a population of about 65 million inhabitants where the country's growing population is expected to reach 90 million in the year 2025 increasing the demand for the already scarce water and arable land. Of this water almost 85% is allocated for agriculture with overall irrigation efficiency lies between 65-75%, whereas water allocated for domestic and industrial uses is less than 15%. Based on the measures towards water resources management, Egypt is facing serious challenges such as deterioration of water quality and the growing demand-supply gap.

Water quality degradation is a significant element in water resources development. Increased industrial growth, together with intensified agriculture, has put a direct impact on the quality of both surface and groundwater. Thus, availability of water became constrained by its degraded quality, which limited its use for specific purposes. Industrial activities, as well as urban centers, negatively affect the water quality of neighboring water bodies as wastewater is dumped into them without proper treatment.

Another major challenge is the fragmentation of water management among different institutions. Water management also lacks coordination among different sectors. Therefore, there must be a policy adopted to clarify the responsibilities and

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coordination among the different institutes. Also, public awareness concerning the value of water should be raised among all stakeholders.

These challenges and weaknesses require a strong emphasis on improving the management of water resources based on well-prepared policies and strengthened institutional arrangements. Water policies, in this respect, should be prepared within the context of integrated framework. This framework takes into account the interdependencies among sectors and protects aquatic ecosystems. It also helps in establishing improved coordination among institutions, consistent regulations, and sound policies. The integrated framework can improve the efficiency in water management through greater reliance on decentralization, user participation and privatization.

The scarcity of water supplies, which are badly needed to meet the needs of population growth and rising standard of living, has given cause of action in formulating the national development plans. Water planners and decision-makers are being increasingly involved in devising ways to optimize the use of the available water supplies, meanwhile augmenting the available water resources by conventional and non-conventional sources. The latter includes two programs, one of which is the reuse of agricultural drainage water, and the second is the treatment of sewage effluent and its reuse mainly for irrigation purposes, which are the subject of this paper. New development projects, e.g. El-Salam and Toshka projects, are being implemented which will have a large impact on the distribution and use of presently available water resources. Major water quality problems are still limited to a number of scattered black spots but proper attention will have to be given to the effects of continued population growth and expected socio-economic developments on water quality.

2. STATE OF THE WATER RESOURCES

2.1 Conventional Water Resources

The conventional water resources in Egypt are limited to the Nile River, the groundwater in the Delta, Western Deserts and Sinai, as well as the rainfall and flash floods. Each resource has its limitations on use. These limitations relate to quantity, quality, location, time, and cost of development.

The Nile is the predominant source of fresh water in Egypt. Presently, its flow rate relies on the available water stored in Lake Nasser to meet needs within Egypt's annual share of water, which is fixed at 55.5 Billion Cubic Meters (BCM) annually by virtue of an agreement signed with Sudan in 1959.

Apart from the Nile waters, Egypt has no effective rainfall except for a narrow strip along the northern coastal area where the average rainfall does not exceed 200 mm (about 1.5 BCM/yr.). This amount of rainfall cannot be considered a reliable source of water due to its spatial and temporal variability.

Groundwater exists in the Western Desert within the Nubain sandstone aquifer that extends below the vast area of the New Valley and its sub-region East of Owaynat. This aquifer stores about 200,000 BCM of fresh water. However, this groundwater occurs at great depths and the aquifer is generally non-renewable. Therefore, the utilization of such water depends on pumping costs and its depletion rate versus the potential economic return over the long run.

Groundwater in Sinai exists mainly in three different water-bearing formations: the shallow aquifers in Northern Sinai; the valley aquifers; and the deep aquifers. The shallow aquifers in the Northern part of Sinai are composed of sand dunes that hold the seasonal rainfall, which helps in fixing these dunes. The aquifers in the coastal area are subject to salt-water intrusion. The total dissolved solids in this water range from 2,000 to 9,000 ppm.

The groundwater aquifer underlying the Nile Valley and Delta is recharged by seepage losses from the Nile, the irrigation canals and drains, and the deep percolation of water from irrigated lands. The total available storage of the Nile aquifer is estimated at about 500 BCM but the maximum renewable amount (the aquifer safe yield) is around 7.5 BCM. The existing rate of groundwater abstraction in the Valley and Delta regions is about 4.8 BCM/year, which is still below the potential safe yield of the aquifer.

2.2 Non-Conventional Water Resources

Non-conventional water resources include agricultural drainage water, desalination of brackish groundwater and/or seawater, and treated municipal wastewater. Desalination is practised on a small scale at present, mainly along the Red Sea coast. Treated municipal water is presently in the research and pilot testing stage. Reuse of agricultural drainage has been practised for many years. Plans are underway to increase this source in future. Agricultural drainage reuse is considered a significant water source and therefore warrants separate discussion.

2.2.1 Reuse of Agricultural Drainage Water

The agricultural drainage of the southern part of Egypt returns directly to the Nile River where it is mixed with the Nile fresh water and reused for different purposes downstream. The total amount of such indirect reuse is estimated to be about 4.07 BCM/year in 1997/98. This drainage flow comes from three sources; tail end discharges and seepage losses from canals; surface runoff from irrigated fields; and deep percolation from irrigated fields (partially required for salt leaching). The first two sources of drainage water are of relatively good quality water. The deep percolation component is more salty and even highly saline, especially in the northern part of the Delta, due to seawater intrusion and upward seepage of groundwater to drains.

In addition, it is estimated that some 0.65 BCM/year of drainage water is pumped to El-Ibrahimia and Bahr Yousef canals for further reuse. Another 0.235 BCM/year of drainage water is reused in Fayoum while about 0.65 BCM/year of Fayoum drainage is disposed of in Lake Qarun. In the Delta region the amount of agricultural drainage water reuse was estimated in 1997/98 to be around 3.50 BCM, in addition to about 0.3 BCM lifted to Rosetta branch from west Delta drains. This constitutes the official reuse carried out by pumping stations of the Ministry of Water Resources and Irrigation (MWRI). Additional unofficial reuse, done by the farmers themselves when they are in short of canal water, has been estimated to be around 2.8 BCM.

The remaining drainage water is discharged to the sea and the northern lakes via drainage pump stations. The total amount of drainage water that was pumped to the sea during the year 1997/98 has been estimated to be 12.94 BCM with overall average salinity of 2400 g/m^3.

Reuse of agricultural drainage water in the Delta is limited by the quality of the drainage water. Taking the salt concentration as an important parameter, the level of salinity increases from upstream to downstream but in most of the Valley and in the southern part of the Delta region, the salinity remains below the critical level of 1,000 ppm making it possible for reuse. However, in the northern part of the Delta region, large quantities of salt seep through groundwater to the drainage water due to the sea water intrusion. The amount of seawater that seeps into the drains is estimated to be about 2.0 BCM/year. This water is pumped back to the sea and northern lakes to maintain the salt balance of the system.

2.2.2 Desalination of Water Resources

Desalination of seawater in Egypt, as a source of water, has been given low priority due, in part, to its high cost (L.E. 4 - 7/m^3). Nevertheless, it may be feasible to use this method to produce and supply drinking water, particularly in remote areas where the cost of constructing pipelines to deliver Nile water is relatively high. It is expected that desalination plants for drinking water and industrial use in areas where no other cheaper resources are available, will be developed as the demands grow in the year 2050. However if brackish (ground) water is nearby available in sufficient quantities, this may be the preferred sources for desalination, depending on the distance to source.

Desalination is practised in the Red Sea coastal area to supply touristic villages and resorts with adequate domestic water supply where the economic value of water is high enough to cover the treatment costs. It may be crucial to use such resource in the future if the growth of the demand for water exceeds all other available water resources. However, its use will depend on technological development in this field.

2.2.3 Treated Wastewater

The concept of reusing sewage after primary treatment for agriculture has been practised since 1925 in the eastern desert area, outside Cairo. An area of 4,000 fed of desert lands was cultivated and successfully produced citrus fruit, date palms and pecan nuts. However, interest in the use of treated wastewater has accelerated significantly since 1980. The population has increased significantly, resulting in more and more wastewater being produced in urban and rural areas. The centralized sewage treatment works produce large quantities of treated wastewater, making their use for agriculture a viable alternative.

Wastewater is considered as a nutrient-rich source that can be used for agricultural production and thus help alleviate food shortage, with reduced use of fertilizers. Treated wastewater can be safely used for public parks and recreation centers, landscape areas and golf courses. It could also be used for industrial purposes and groundwater recharge. It can help in controlling dust storms and desertification through irrigation and fertilizing tree belts.

Currently, the total volume of treated wastewater from the New Cities and Canal Cities is in the order of 1.4 BCM per year, of which more than 85% are from the New Industrial Cities. The reuse potential obviously will depend on the quality of the wastewater. This depends on the type of treatment of domestic wastewater and especially on the industrial pollutants and their removal during the on-site treatment process.

Moreover, the total quantity of reused treated wastewater is 0.7 BCM/yr of which 0.26 BCM is undergoing secondary treatment and 0.44 BCM undergoing primary treatment. By the year 2017, 2.5 BCM/yr of treated wastewater is envisaged to cultivate 280,000 feddan, mainly with timber trees and industrial non-food crops. In the planning for horizontal development by the year 2017, an amount of 2.5 BCM/yr of treated wastewater from Cairo and Alexandria is planned to irrigate 280,000 feddans located in South Helwan (40,000 fed), Zenin and Abu Rawash (70,000 fed), Berka and Gabal El Asfar (100,000 fed) and El-Hammam (70,000 fed) with a total cost of 1.41 billion LE to cultivate mainly timber trees and industrial crops (cotton, flax, jut, etc.).

The present paper will tackle in detail the reuse of agricultural drainage water and the treatment of sewage effluent and its reuse mainly for irrigation purposes.

3. AGRICULTURAL DRAINAGE WATER USE IN EGYPT

The land drainage system in Egypt has been developed since the turn of the last century into a very efficient network. The drainage system has three main objectives: 1) to control groundwater level in the irrigated fields below the root zone thus avoiding waterlogging, 2) to facilitate leaching of accumulated salts in the top soil thus avoiding land salinization, and 3) to collect excess irrigation water thus offering an opportunity for reuse in irrigation. The cultivated area of Egypt (about 8 million acres) is sustained by adequate drainage systems starting with field drains mainly of the subsurface type and ending with main system of open drains for collecting and transporting drainage flow. The drainage water comprises runoff of applied water, water leached through the soil, groundwater, and industrial and domestic wastewater.

Most of the drainage water from the Nile Valley (Upper Egypt) flows back by gravity to the Nile as return flow. It is estimated at about 2.5 BCM annually. This slightly affects the quality of the Nile water from Aswan to Cairo. In the Nile Delta, the drainage system is rather intensive and the drainage water is discharged into the Northern Lakes or the Mediterranean Sea. Presently, it amounts to nearly 12.5 BCM/year. The Fayoum region has a deep depression forming a closed basin and about 0.6 BCM of drainage water is discharged annually into Lake Qaroon, where water is only lost by evaporation.

With the increasing need for water for vertical and horizontal agricultural expansion, and with the scarcity of new water resources, the Ministry of Water Resources and Irrigation (MWRI) has, over the past decades, thoroughly considered the issue of reusing drainage water. This has now become a national policy. The policy calls for pumping drainage water from main and branch drains and mixing with fresh water in main or branch canals. The criteria for mixing are based on the sustainability of the blend for irrigation of all crops.

Preliminary investigations revealed that sustainable quantity of drainage water flowing to the sea has reasonable salinity, which allows its reuse for irrigation purposes. This is because the irrigation network was originally designed to operate for 24 hours daily, yet most farmers have abandoned night irrigation. Normally, this has led to increased drainage water and decreased salt concentration. However, the inclusion of this type of water requires careful and detailed evaluation of its quality.

3.1 El-Salam Canal Project as a Model of Agricultural Drainage Reuse

El-Salam Canal is one of the five-mega irrigation projects in Egypt located in northern Sinai. The Egyptian Government envisages the reclamation of an estimated 620,000 feddans of desert situated along the Mediterranean coast of Sinai (220,000 feddans of which lie west of Suez Canal and about 400,000 feddans east of Suez Canal) by diverting considerable amounts of agricultural drainage water to newly reclaimed areas after blending with Nile water. El-Salam Canal water is a mixture of 2.11 billion m^3/year of the Nile fresh water from the Damietta branch mixed with 1.905 billion m^3/year of the drainage water from Bahr Hadous and 0.435 billion m3/year of El Serw drainage water. So the total quantity of water is nearly 4.45 billion m^3/year with a ratio of Nile water to drainage water approximately 1:1. This ratio was determined to reach an amount of total dissolved solids (TDS) not more than 1000-1200 mg/L to be suitable for cultivated crops. The Egyptian Academy of Science and Technology financed a research project namely "Treatment of Nile Water of Sinai" with the aim of preparing the environmental baseline profile that helps in building up database as well as obtaining conclusive scope of the negative impacts that arise from implementation of El-Salam project. In addition, the project aims at investigating the different water resources and actual mixing conditions in order to recognize their quality and possible risks.

The project also aims at re-charting the Egyptian population map, improving income distribution and generating employments through the settlement of small-holders and graduates from among the rural population of the over-populated area of Egypt. Furthermore, the transfer of Nile water into Sinai will help create new communities along the Canal, meanwhile using the valuable economic treasures in Sinai, such as the huge natural resources including medicinal plants, animals and valuable rock forms and minerals.

3.2 Agricultural Drainage Water Monitoring Program

The Ministry of Water Resources and Irrigation of Egypt was entrusted to carry out a long-term monitoring program to give answers to decision- and policy-makers about the quantity and quality of drainage water and its locations. A monitoring network of 90 measuring locations on the main drains in the Nile Delta and Fayoum was established in the early 1980's, providing daily measurements of drainage flow and bi-weekly salinity measurements, as well as other chemical components. Since then, the network has been continuously maintained and upgraded to furnish reliable measurements. The current monitoring network in the Nile Delta and Fayoum has been enlarged to consist of 140 sites for monitoring the quantity and quality of drainage water both in the main and branch drains with monthly frequency (Figure 1). The number of parameters is increased to 31, taking into consideration toxicological and microbiological parameters, oxygen budget, anions/cations, metals and trace elements, in addition to the classical parameters.

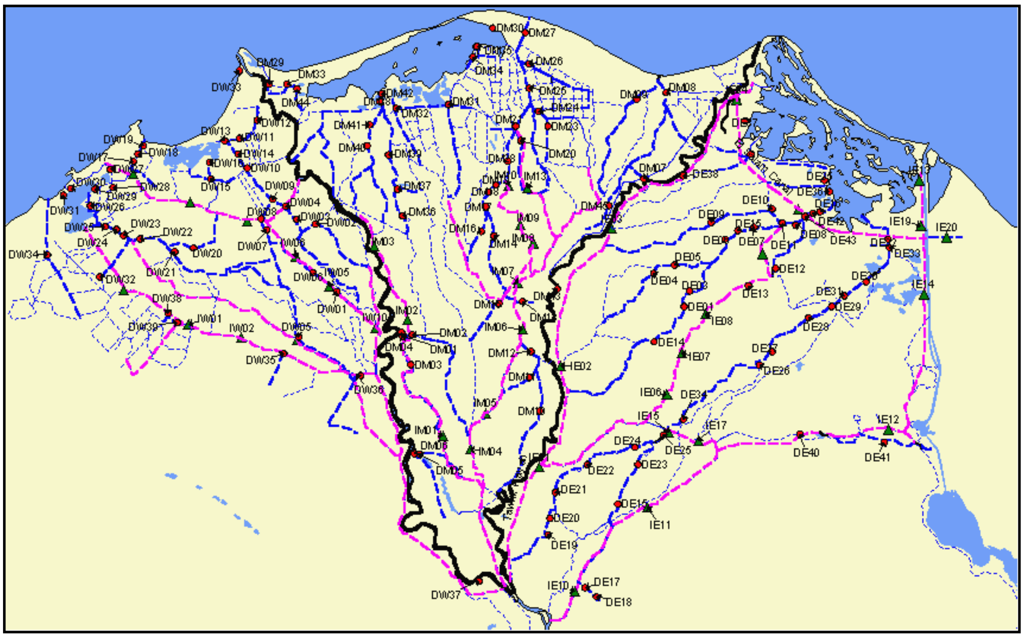

Figure 1. The Nile Delta monitoring network

The field measurements and laboratory analysis are regularly stored in an interactive database, continuously maintained and finally linked with a Geographical Information System (GIS). The monitoring results are routinely published in yearbooks and disseminated to all concerned decision-makers.

Historical data is now available about drainage water quantity and quality in the Nile Delta for the last 15 years. Many important decisions regarding the existing and future plans of drainage water reuse were taken on the basis of this information.

The monitoring program clearly reveals that the drainage water quantity changes with time, depending on water use policies and the management of the main supply system. The variations occur from month to month, season to season, and year to year. The average drainage water discharged annually to the sea is 12.5 BCM. The measured drain discharges to the sea are not entirely excess irrigation water. They include brackish groundwater, sea water and municipal and industrial (M&I) wastewater discharges.

In addition to El-Salam canal project which mixes 2 BCM drainage water from Bahr Hadus and Lower Serw drains with 2 BCM fresh water from Damietta branch to irrigate 620,000 acres in Sinai, El-Umom project reuses 1 BCM drainage water of Umom drain to irrigate 500,000 acres in Nubaria.

This is, in total, an additional 3 BCM reuse expansion plan. This will bring the total drainage water reused by the year 2017 to 8.3 BCM per year. The potential to increase this reused quantity beyond that depends on many factors among which are the quality of the drainage water, the location where this water is available, the salt balance of the Delta and the tolerance of the cultivated crops.

3.3 Simulation and Modeling

The quantity and quality of drainage water are determined by the supply, distribution and management of water for meeting the demands especially for irrigation. They are products of the quantity and quality of the water originally used, the irrigation practices and water management, the processes it undergoes and the physical and chemical characteristics of the transporting media and the external interventions. Such complex situation makes the prediction of the drainage water quantity and quality a difficult job. However, predictions are important for planning and efficient utilization of water resources, especially when changes in water management, water reallocation, and crop patterns are expected.

The physical, hydrological, agronomic and functional relationships at the regional and field levels have been combined in an integrated water management simulation model developed by the Drainage Research Institute affiliated to the National Water Research Center of Egypt. It is a package of programs and physical-based sub-model; each of them has a specific function related to water flow and management in a region like the Nile Delta.

3.4 Drainage Water Guidelines

It is well recognized that drainage water is generally of less quality than fresh river water. There are a number of issues to be addressed when reusing low quality water, most of which are related to environment and health. Thus, judging the suitability of such water for irrigation means adhering to certain criteria and practices.

The Drainage Research Institute extends its activities to monitor the impact of present practices of reusing drainage water for irrigation on soils, crops, human health and on the environment. The physical and chemical characteristics of soils and crop growth and yields were evaluated in 100 sites distributed over the East, Middle and West of the Delta. The size of each site is about one acre. They represent areas irrigated by: 1) fresh water, 2) blend of irrigation and drainage water, 3) drainage water only, and 4) alternate use of freshwater and drainage water at certain stages of crop growth.

The results of monitoring and experimental work were used to develop guidelines for using drainage water in irrigation on environmentally sound basis. The guidelines enable the user to rate salinity hazard factors and suggest irrigation and crop management practices to overcome hazards, forming a decision support system for the use of drainage water in irrigation for sustainable crop production. The guidelines are intended for use on currently cultivated lands as well as on new land being brought into production by reclamation. They are meant to be applied to a specific crop or to a crop rotation that is to be irrigated with a water of known quality under particular soil salinity and hydrologic conditions. The guidelines contain three matrices organized in categories of crops: salt tolerant, moderately salt tolerant, and salt sensitive crops. The matrices are designed to identify and compare the relative potential hazard of crop yield reduction and soil salinization when using various types of irrigation water (DRI, 1997).

Three major effects are considered in the organization of each matrix: the direct impact of irrigation water quality on crop yield via irrigation water salinity and sodicity hazard; irrigation water management related to consumptive use and leaching requirement of the crop; and soil quality. This last factor rates the potential of the soil to remain a suitable medium for plant growth related to soil salinity and sodicity.

The guidelines also include criteria for environmental protection and public health preservation. Additionally, they rate the degree of socio-economic vulnerability of the farmers involved in the use of drainage water, and list institutional measures indicated to mitigate the risks.

4. POTENTIAL OF TREATED WASTEWATER RESUE IN EGYPT

4.1 Wastewater as a Resource

Wastewater has an important role to play in water management as a substitute for fresh water in irrigation. By releasing freshwater sources for potable water supply and other priority uses, wastewater reuse contributes to water conservation and takes on an economic dimension.

Discharging untreated or partially treated wastewater to the environment gives rise to pollution in surface and groundwater, and certainly leads to land pollution. Planned reuse of treated wastewater for irrigation prevents such problems and reduces the resulting damages, which can partly offset the costs of the reuse scheme. Another way of reusing wastewater is through artificial recharge of the aquifer system with partially treated wastewater.

Studies in many countries have shown that, with proper management, crop yield may increase by irrigation with primary and secondary treated wastewater effluent.

Experience of directly reusing treated effluent is limited in Egypt. So far, effluents from existing treatment plants are discharged to natural streams and are then reused for irrigation.

With population growth and continuing urbanization, the volume of wastewater continues to grow and its disposal becomes a serious problem. Reclaiming and reusing municipal wastewater for irrigation is an easy and useful means of disposal and an attractive and innovative alternative to meet increasing water demand.

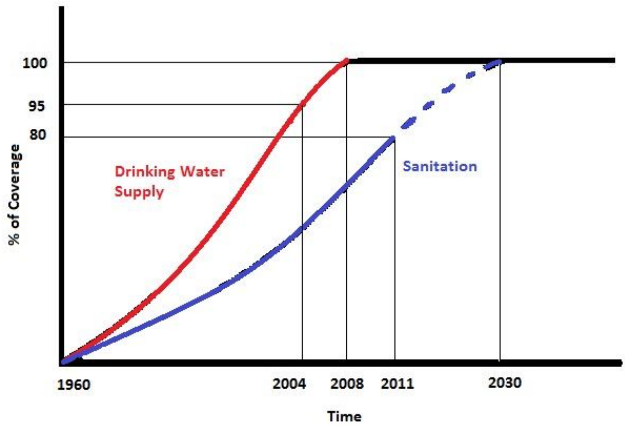

Figure (2). Percentage of coverage of drinking water supply and sanitation services since 2004 till 2017

Generally speaking, figure (2) shows that the percentage of coverage of sanitation services during the years 2004 and 2008 were nearly half the coverage of the drinking water supply services, hence creating major wastewater problems. Since 2008, the coverage of drinking water supply reached 100% while the sanitation services were still lagging behind. Presently, in 2011, the sanitation services covered 80% of the demand, with a projection to 100% in the year 2030 to satisfy most of the required needs for safe wastewater disposal and reuse.

4.2 Research on Wastewater Reuse

Several studies on wastewater use for agriculture and its impact on the soil and the environment are being conducted by the Ministry of Agriculture and Land Reclamation (MALR).

The research studies include:

- Proper use of wastewater and sludge;
- Appropriate irrigation methods for reusing wastewater;
- Changes in the chemical and physical properties of the soil;
- Potential heavy metal toxicity to crops irrigated with wastewater;
- Best soil-water management practice in terms of the amount and frequency of water application.

In the last five years, active pilot wastewater-irrigated forest projects were initiated by MALR in nine different locations in Egypt (Riad, 2000). The areas ranged from 50 fed as in Abu Rawash to 1000 fed as in Luxor. The results showed that the tree varieties selected in the pilot sites have excellent economic value in timber production. Also inter-cropping other crops with trees such as ornamental plants and cut flowers has proven fully possible which helps obtain faster economic returns.

4.3 Present and Planned Reuse of Treated Sewage Effluent

At present, domestic and municipal use of water is 4.5 BCM/yr. The current per capita per day wastewater generation rate is 190 liters in urban areas, 77 liters in rural areas and 135 liters in the Delta in average. The sewage flow in the Delta is expected to increase by 1.5 times in twenty years.

The total production of potable water treatment plants is 6.6 BCM/yr and sewage treatment plants are about 3 BCM/yr. The distribution of existing sewage treatment plants is mainly in the capital and major cities. It has been estimated that the total quantity of reused treated wastewater for irrigation is 0.7 BCM/yr in 2000, of which 0.26 BCM secondary treated and 0.44 BCM primary treated.

Wastewater from domestic sources contains about 97 % water and 3% organic and non-organic solids. These solids are rich in some of the nutrients necessary for plant growth such as nitrogen, phosphorus, potassium, boron and zinc. The organic content of sewage effluent improves the physical and chemical properties of sandy soils by increasing their water-retention capacity.

5. LAWS AND DECREES CONTROLLING WATER QUALITY

Effective programs to control water quality deterioration depend upon the existence of adequate legislation, supported by regulatory standards that specify the quality of water for the specific use.

The legal framework for protecting water quality in open streams has been established in a number of laws and decrees during the second half of the last century. The most important of all these are:

- Law 93/1962 concerning drainage of liquid waste (Ministry of Housing and Utilities).
- Law 12/1984 on irrigation and drainage regulating the use of water, including groundwater.
- Law 48/1982 involving the protection of the River Nile and its waterways from pollution, implemented by decree 8/1982 of MWRI. This law defines various types of waterways and regulates the discharge of liquid wastes in waterways. MWRI is made responsible for the licensing of wastewater discharge, whereas the Ministry of Health is responsible for monitoring. The decree specifies standards for the disposal of wastewater under different conditions and for receiving water.
- MWRI is now working on the Amendment of Law 12 for year 1984 in addition to the Executive Regulation of Law 48/1984.

- Law 4/1994 on Environmental Protection describing the tasks of the EEAA, providing general rules for protection of the environment, and regulating air pollution and the use and protection for the marine environment.

6. NATIONAL POLLUTION CONTROL MEASURES

The MWRI faces multi-dimensional challenges in sustaining the current reuse and promoting more drainage water reuse over the next decades.

The challenge is to develop pollution control plans that are cost-effective, compatible with the state of social and economic development and provide achievable benefits.

The Government of Egypt has promoted concerted action in order to protect the water resources from over-consumption, pollution and rising threats from limited water resources and increased demands. These actions are under implementation and it will have, in the very near future, a positive impact on water resources and Egypt's development.

7. THE HOLDING COMPANY: its Establishment, Goals, Services, Challenges and Achievements

The holding company was established by Presidential Decree no. 135 for the year 2004. Under this decree, the fourteen largest municipalities in the country were transformed into subsidiary companies of the Holding Company.

The strategic goals of the holding company were to improve the quality of customer service and satisfaction, to achieve financial stability of the water and wastewater sector, to assure professional development of the Holding Company and subsidiary companies, to improve the skills of the sector and to protect the sectors investment.

The Holding Company had a wide impact on the country such as, serving 12 governorates in addition to parts of Giza and Qalioubeya, delivering drinking water to 44 million people by the holding company subsidiaries, delivering wastewater services to 25 million people. The holding company subsidiaries in general produce 14.7 million m^3 of drinking water/ day and treat 5.3 million m^3 wastewater/ day. In 2006, the company started a process of establishing another ten subsidiary companies to cover the water and wastewater services all over the country.

The Water and Wastewater sector functions under several organizations which are: the Holding Company for Water and Wastewater (HCWW), the National organization for Portable Water and Sanitary Drainage (NOPWASD), the Central Organization of the Execution of Cairo and Alex portable Water projects (CAPWO), and the Egyptian Water Regulatory Agency (EWRA)

In spite of the progress done, the Holding Company and its subsidiary companies still face a lot of challenges such as: Low tariffs leading to a weak financial position, overstaffing, lack of skilled staff in financial and technical fields, weak billing and collection systems, reliance on manual systems, the insufficient coordination between NOPWASD and CAPWO and the subsidiary companies, the inadequate O & M for the plants and networks, and other problems with the accuracy of data available.

The Holding Company has tangible achievements in the fields of customer satisfaction, technical assistance, human resources development, financial stability and in-service expansion.

1- In the field of **Customer Satisfaction**, the holding company has established a hotline 125/ 175 in all subsidiary companies to receive customer complaints around the 24 hours.

2- In the field of **technical assistance** many projects have been implemented such as: a Master Plan founded by the European Union, Integrated Sanitation project, Water Meters, Central Laboratories, Wireless Network, Website to connect subsidiary companies with each other and with the Holding Company, and the Leakage control project.

3- In the field of **human Resources Development**, the HCWW has taken part in several programs such as: personal activity programs for its employees through workshops and training, sending training expeditions abroad, encouraging the participation in scientific conferences locally and internationally, and preparing for the development of training centers in the subsidiary companies to increase its resources through training in other countries, encouraging the participation of scientific universities and institutes in solving problems, holding monthly meetings with all chairmen of the subsidiary companies to pursue the performance, and updating employment plans in the subsidiary companies by establishing a new organized database for the current employees.

4- In the field of **financial stability**, the Holding Company designed the financial and accountant system for HCWW, recorded automatically from 1/9/2004. It applied the modified and unified account system in the HCWW and its subsidiaries, it created a coordination links between the Ministry of Housing and the Ministry of Finance to solve the accumulated shortage and debts of the subsidiary companies. The Holding company also established a cost accounting department in Sharqia and Gharbia companies.

The Holding Company also prepared indicators of financial performance in all its subsidiary companies, and established and supported economic analysis management in each subsidiary company to be able to follow its performance on the financial level. It also encouraged the subsidiary companies to increase their resources through tasks implementation for others, in addition to increasing the subsidiary company resources through the financial gains from advertisement on tanks and the walls of water stations. Additionally, the holding company also does an accurate study for the Electricity Department and analyzes its tariffs to reach a real accountant way that agrees with sovereign decrees.

8. STRATEGY FOR THE FUTURE

Water is the most manageable of the natural resources, since it can be transported, stored, diverted and recycled. The limited water supplies have led to a growing interest in the rational use of this increasingly important resource. Consequently, reuse of agricultural drainage water and treated sewage effluent is an accomplished and accepted fact, with a high degree of social and political commitment.

Faced with these challenges, the Ministry of Water Resources and Irrigation started an integrated management approach that combines all available resources (freshwater canals, drainage water and groundwater) to meet the water demands of different users. The approach requires full coordination between government institutions at all levels, and active participation of water users in planning, managing and operating irrigation and drainage systems.

As agriculture expands to new areas in the Nile Valley, the Ministry of Water Resources and Irrigation budget is increasingly strained. To reduce the Government's financial burden, the Ministry is progressively decentralizing the management of water/irrigation to water boards organizations based on representation.

The Government plans to increase habitable land from the current 5% to 25%, and increase the cultivable land area from the current 8 million acres to 11.4 million acres by 2017. Reflecting its commitment to greater private sector participation in development projects, the Government created two Holding Companies to manage, operate and maintain the irrigation/drainage networks in Toshka and North Sinai activities. Also, the companies are planned to provide appropriate services to investors and small farmers.

To properly assess the future status of water resources in Egypt, the national water resources plan is considered as a model example document towards development of the integrated water resources management. The document focuses on the physical improvements necessary to satisfy the supply-demand imbalance. The totality in the approach to water resources/agricultural/urban water management is significantly expressed throughout the plan. The national plan emphasizes the coordination between ministries, stakeholders, NGOs and civil societies to ensure the successful implementation and sustainability for the integrated management of the water resources. Institutional reform, financial and privatization, planning and cooperation, and gender issues were also considered in the plan.

The main features of the water policy document towards year 2017 (MWRI, 2000) provides an evaluation for the existing water resources, the future water demands by year 2017, and the main guidelines for policies and strategic plans for water resources development. Governing drainage and irrigation and protecting Nile River and watercourse contain legislative aspects for an integrated water resources management plan.

Looking to the future, the Ministry of Water Resources and Irrigation has developed a future vision for the year 2050. This vision is set to safeguard Egypt's demand from currently available water resources which include Egypt's share of the Nile Water, as well as the groundwater, and the non-conventional resources. This could be implemented by increasing sea water desalination for drinking water purposes in the coastal areas without relying on the additional increase of Egypt's share of the Nile Water.

The objectives of the water resources vision till 2050 are:

- Providing clean drinking water for 100 % of the population.
- Providing adequate water both in quality and quantity for different development purposes; such as agricultural, industrial, navigational, touristic purposes etc.
- Maximizing the economic, social and environmental role of water resources.

The main pillars of the vision are:

- Making the best agricultural, social and environmental use of the available water resources by means of irrigation improvement and changing crop patterns.
- Applying Integrated Water Resources Management approach through developing governmental and non-governmental institutions, as well as enforcement of laws and legislations.
- Allocating different conventional and non-conventional water resources (cooperation with the Nile Basin countries - desalination)
- Supporting and effectuating the private sector role.
- Countering pollution as well as preserving water resources.

This could be accomplished through cooperation with various stakeholders and institutional reform by means of merging different sectors as well as purging incompetent ones to cope with the potential changes.

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