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Rational water use in Egypt

Alaa El-Din Abdin¹ and Ibrahim Gaafar²

¹ Director, Strategic Research Unit, National Water Research Center, Egypt

² Researcher, Strategic Research Unit, National Water Research Center, Egypt

Abstract. In Egypt, the acceleration of economic and demographic development, with rapid urbanization, growing industrialization and agriculture, has stepped up the pressures on the country's water resources, triggering an increase in their demand accompanied by the deterioration of water quality. This situation is alarming as Egypt is an arid country that depends on a single source of water which is the Nile River. Besides the population growth, social factors (poverty, quality of life, crop pattern, unequal distribution of water and consumer's behavior), physical variables (water resources and land expansion), economic and political elements are the main driving forces of water scarcity. Demand-oriented measures that can be implemented in Egypt include: i) shifting to less water-demanding crops, ii) improving the efficiency of the existing public water supply system by reducing losses, detecting leakage and improving irrigation distribution and conveyance efficiency, iii) introducing tariffs for water conservation which might include various kinds of land or crop taxes, production charges, water pricing, or subsidies for water conservation, and iv) launching public awareness campaigns aimed at advocating a new water culture in a society based on the principle of conservation. A number of measures towards the rational use of water are already applied but still need extra efforts to be fully successful. Enhancing the institutional organizations, involving the private sector, stringent laws and cooperation with the Nile Countries are considered a must to increase the water use efficiency, control water demand and reduce the over irrigation and the misuse of water. Optimum use of water resources is implemented through the reuse of drainage water, recycling the domestic and industrial wastewater and desalination. Co-operation with the riparian countries of the Nile Basin, through the Nile Basin Initiative, is expected to implement Upper Nile Projects and in return to lead to additional inflow into Lake Nasser. This paper can be considered as an attempt towards highlighting the ways and means for a rational use of water so as to improve water use efficiency in Egypt. Emphasis will be laid on how to utilize the available quantity of water as well as how to get additional quota for Egypt through the Nile Basin Initiative projects.

Keywords. Egypt – Water resources – Demand-oriented measures – Rational use of water – Water use efficiency.

Utilisation rationnelle de l'eau en Egypte

Résumé. En Egypte, l'accélération du développement économique et démographique, parallèlement à l'urbanisation rapide, l'industrialisation croissante et l'expansion de l'agriculture, a renforcé la pression exercée sur les ressources en eau du pays, provoquant ainsi une augmentation de la demande et par là même, une détérioration de la qualité de l'eau. La situation est alarmante étant donné que l'Egypte est un pays aride qui dépend d'une seule source d'eau, à savoir le Nil. A part l'accroissement de la population, les conditions sociales (pauvreté, qualité de vie, systèmes de culture, distribution inégale de l'eau et comportement du consommateur), les variables physiques (ressources en eau et expansion des terres), les forces économiques et politiques sont autant de facteurs déterminants de la pénurie d'eau. Il est donc utile d'envisager l'application de mesures orientées vers la demande, et plus précisément : i) opter pour des cultures moins exigeantes en eau, ii) accroître l'efficacité du système public d'approvisionnement en eau, en réduisant les pertes, en décelant les fuites et en améliorant la distribution de l'irrigation et l'efficacité de distribution de l'eau iii) appliquer un tarif pour la conservation de l'eau qui pourrait inclure différents types d'impôts sur les terres ou les cultures, les charges de production, la tarification de l'eau ou les subventions pour la conservation de l'eau et iv) lancer des campagnes de sensibilisation pour diffuser une nouvelle culture de l'eau dans une société basée sur le principe de la conservation. Bien que un certain nombre de mesures aient déjà été adoptées pour une utilisation rationnelle de l'eau, des efforts supplémentaires s'avèrent nécessaires afin d'assurer des résultats satisfaisants. Le renforcement des organisations institutionnelles, l'implication du secteur privé, une législation solide et rigoureuse ainsi que la coopération avec les pays du Nil sont un impératif pour pouvoir accroître l'efficacité d'utilisation de l'eau, contrôler la demande et réduire la surirrigation et la malutilisation de l'eau. De toute évidence, une utilisation optimale des ressources en eau comporte la réutilisation de l'eau de drainage, le recyclage des eaux usées ménagères et industrielles et la désalinisation. La coopération

avec les pays riverains du bassin du Nil, dans le cadre de l'Initiative du Bassin du Nil, devrait prôner la mise en oeuvre des Projets du Haut Nil et permettre d'accroître le niveau d'alimentation du lac Nasser. L'objectif de cette étude est donc de parcourir les moyens et les modalités nécessaires pour parvenir à une utilisation rationnelle et améliorer l'efficacité d'utilisation de l'eau en Egypte. L'accent est mis sur la manière d'utiliser les quantités d'eau disponible et d'obtenir une quote-part supplémentaire en Egypte à travers les projets de l'Initiative du Bassin du Nil.

Mots-clés. Egypte – Ressources en eau – Mesures orientées vers la demande – Utilisation rationnelle de l'eau – Efficacité d'utilisation de l'eau

I – Introduction

Water resources in Egypt are becoming scarce. Surface-water resources originating from the Nile are currently fully exploited, while groundwater sources are being brought into full production. Egypt is facing increasing water needs, demanded by rapidly growing population, increased urbanization, higher standards of living and by an agricultural policy which emphasizes expanding production in order to feed the growing population. The population is currently increasing by more than one million persons a year. With a population of approximately 74 millions in 2008, Egypt is expected to see an increase to some 100 millions by 2025. The most critical constraint facing Egypt is the growing shortage of water resources accompanied by the deterioration of water quality.

Water resources in Egypt are limited to the Nile River, rainfall and flash floods, deep groundwater in the deserts and Sinai, and potential desalination of sea and brackish water. Each resource has its usage limitation, whether these limitations are related to quantity, quality, space, time, or exploitation cost. Egypt receives about 98% of its fresh water resources from outside its national borders. This is considered to be the main challenge for water policy and decision makers in the country as the Nile River provides the country with more than 95% of its various water requirements.

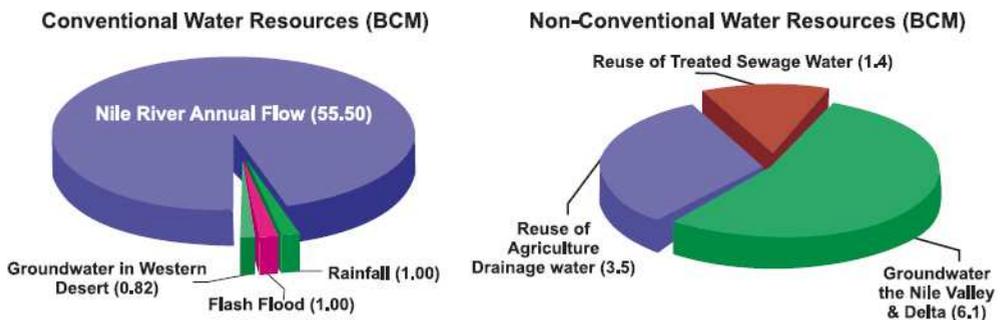


Figure 1. Water Resources of Egypt.

As illustrated in figure 1, the average annual quota of Egypt from the conventional water is limited in the Nile River which is determined as 55.5 BCM according to the 1959 agreement with Sudan. Another 0.82 BCM per year is utilized from groundwater in the Western Desert, in the Nubian sandstone aquifer, which extends below the vast area of the New Valley Governorates and the region east of Owaynat. Another 1.0 BCM per year is utilized from rainfall along the coastal area and flash floods occurring within short-period heavy storms in the Red Sea area and Southern Sinai that are directly used to meet part of the water requirements or used to recharge the shallow groundwater aquifers. Desalination of seawater in Egypt has been given low priority as a water

resource because the cost of treatment is high compared with other sources (Amer *et al.*, 2005). Desalination is actually practiced in the Red Sea coastal area to supply tourist villages and resorts with adequate domestic water supply where the economic value of the water is high enough to cover the treatment costs.

The non-conventional water resources include the renewable groundwater aquifer underlying the Nile valley and delta, the reuse of agricultural drainage water, and the reuse of treated sewage water. The amount of the groundwater in the Nile valley & delta is estimated at 6.1 BCM per year, the reuse of agriculture drainage water is about 3.5 BCM per year and the reuse of treated sewage water is about 1.4 BCM per year.

These limited quantities of water have to fulfill the Egyptian requirements in the fields of agriculture, which is the largest consumer of water (85%), industry and domestic uses. Increased population needs more water for domestic use as well as horizontal expansion to maintain the per capita of cultivated land. This reclaimed area either will increase the agriculture share of water or will reduce the quantity of water allocated per feddan (in case of fixing the agricultural share of water) which in return decrease the crops' yield. Also development of industry will consume more water which will affect the Egyptian water balance.

II – Water Scarcity in Egypt

Per capita fresh water availability in Egypt dropped from 1893 cubic meters in 1959 to 900-950 cubic meters in 2000 and tends to decline further to the values of 670 cubic meter by 2017 and 536 by 2025 (Abd-El-Hai, 2002). The main reason behind this rapid fall is the fixed water resources and the rising pressure from population growth. However, there are other more important factors in escalating the water issues in Egypt. They do not show direct linkages to the problem but have great contribution in establishing water stress conditions. These driving forces are categorized in four different subgroups as follows:

1. Social forces

The social forces can be viewed at four levels. Figure 2 reports the different layers of the social forces that contribute to escalating the water scarce conditions over time. Impacts of poverty, inequity, cropping patterns and consumer behavior contribute to emerging of water shortages which already exist whereas the population growth and improved quality of life will occur later.

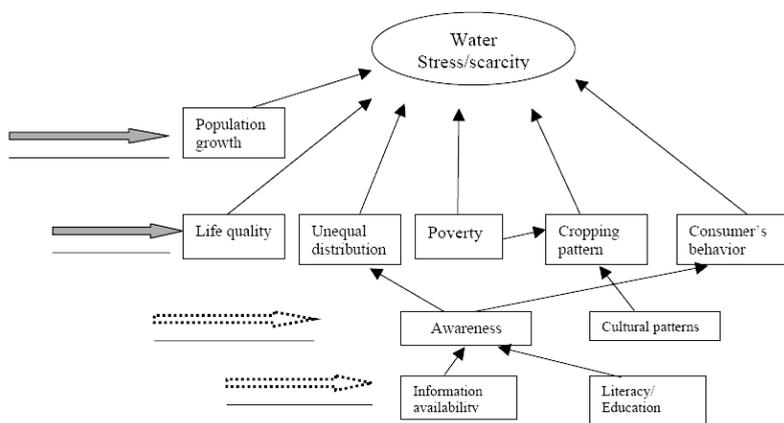


Figure 2. Different Levels of Social Forces Affecting Enhancement of Water Scarcity Conditions.

2. Quality of life

Accelerated economic growth in Egypt during the last decades is reflected in a better quality of life. The main indicators of living standards have improved remarkably over the last 30 years. Social and human development programs and health services have made advances in life expectancy, which has been increased from 55 years in 1976 to 67.1 years in 2001. Advancements in living standards together with population growth have already been reflected in expansion of water consumption levels for domestic use. Domestic water use grew from 3.1 BCM in 1990 (Abu-Zeid, 1991) to 5.23 BCM in 2000 (FAO Aquastat). Further augmentation of the life quality and the population growth will push up water demands.

A. Poverty

Poverty in rural communities of Egypt is still a problem although significant improvements in the standards of living have been made in the last three decades. Human Development Report (2003) estimated that 20.4% of the total rural population is poor and 6.1% is ultra poor⁽¹⁾. The distribution of the poor people in the country is quite uneven and shows significant differences among regions. For example, a number of provinces in the Delta has higher poverty rates than others that reach 35.4% where 10.9% of the population is ultra poor. In other provinces in Upper Egypt, the proportion of the ultra poor population is as high as 41.9%. Often low-income levels and poverty in rural areas limit the farmers' ability to invest in agriculture pushing them to plant the low-cost crops namely water thirsty crops (i.e. rice, sugarcane). This shift in the cropping pattern triggers the increase in water use.

B. Cropping pattern

Cropping pattern plays a vital role in determining the irrigation water demand. During the 1950s, 1960s, and 1970s, the agricultural sector was characterized by heavy government interventions in the production, trade and prices. The reform in the 1980s resulted in the liberalization of prices and government control of the cropping was abolished. Consequently, some changes in cropping patterns were made favoring production of high value-added crops. Among them were the rice and the sugarcane with the highest water requirements among the crops cultivated in Egypt. For example, the annual production of rice rose from 2.4 to 4.5 million tons (UN CCA, 2001) and fields of rice expanded almost by 50 percent (from 1 million feeding to 1.5 million) (MWRI, 2002).

The national survey (1998) shows that the main reason of crop choice is the profitability of crops. The choice of cultivated crops, based on a profit-driven cropping pattern, seems more relevant in this case if the poverty levels in rural Egypt are taken into account. The rice is a high value crop and is likely to be an important contributor to income raising. Thus, the cropping patterns that sometimes lead to water shortages serve the welfare interests of rural families.

C. Consumer's behavior

The water stress conditions are bound to such factors as conscious behavior of the consumer. This derives from the level of education, accessibility and availability of information and cultural patterns. For example, in new lands regardless of the presence of new irrigation systems, farmers still use flood irrigation (MWRI, 2002). They prefer the old methods they are used to and resist to the innovations. The short duration variety of rice finds difficulties to expand in spite of lower water requirement. One of the reasons mentioned is the rice taste which Egyptian farmers do not like. Another factor, which prevents the spreading of short duration rice, is the lack of information on the availability of such varieties. The behavior is also dictated by accessibility of inexpensive, almost "free" irrigation water.

In 1998, a national survey of Egyptian farmers was carried out, aiming at identifying the farmer's awareness, attitudes and practices concerning the water resource management. The study shows

that about 61 percent of male and 29 percent of female farmers know that available water resources in the country are fixed. As mentioned in the introduction, the illusion of abundance of resources is widely spread in the country, so only 21 percent of farmers consider the scarcity problem, that can emerge in the future, seriously enough and 23.6% do not see the problem of scarcity at all. On the other hand, 57 percent of farmers hold the hopes that larger water quota is negotiable. The answers according to the education levels differ significantly showing higher awareness of the problem among higher-educated respondents. Low awareness can be explained with low, 53.1 percent literacy level in rural areas (UNDP, 2003) and poor accessibility to information. The literacy levels of females are lower, which is reflected in considerably lower awareness levels. Awareness about water conservation measures is low as well. Farmers are poorly informed about possibilities for how to decrease the water consumption. As survey indicates only 20 percent of male farmers and 4 percent of females had ideas about how to irrigate with less water; however, about half of the respondents are aware of advantages of night irrigation and almost all of farmers use land leveling (El-Zanaty 1998).

D. Unequal distribution

Unequal distribution of water is another factor that is involved in emerging water stress conditions. It is a result of water overuse at the head of the canal bringing less water toward its ends. Therefore, farmers at the tail of the canal and downstream suffer from water shortages and are forced to abandon cultivation of some part of their land in order to avoid yield losses, whereas at the head of the canal peasants enjoy the abundance of irrigation water. Interviews with farmers showed that some of them located far from the head of the canal were experiencing the losses of the yield due to under-irrigation caused by unequal distribution of water. Unequal distribution of water can be linked to the behavior of farmers who cannot see far going consequences of their actions. So is the abuse and damage of irrigation infrastructure in order to get wider access to water (Malashkhia, 2003). The low cooperation levels and low communication facilities make this problem even more complex.

Farmers cannot always be blamed for their ignorance or low consciousness since the over irrigation practices that lead to water shortages downstream are often induced by unreliability of the water provision in canals. Uncertainty in water availability pushes them to over-irrigate, as they are not sure in future water delivery (Holmen, 1991).

2. Physical variables

A. Water resources

More than 96 percent of all the Egyptian fresh water resources are supplied by the river Nile, which originates from outside the country boundaries and supplies ten countries among which Egypt. Egypt's share of Nile water is limited according to the 1959 international agreement between Sudan and Egypt at 55.5 BCM (Abu-Zeid, 1991). The rest of the water requirements is met by a renewable groundwater with 4.8 BCM/year and a drainage water reuse, which is estimated at 4.5 BCM. Treated municipal and industrial wastewater water returns to the closed water system 0.7 and 6.5 BCM, respectively (UN CCA, 2001). On the other hand, about 3 BCM, from the 55.5 BCM, is lost through surface evaporation from the irrigation system (MWRI, 2002).

Table 1. Present and projected water resources in BCM.

Source	2001	2017
The Nile	55.5	57.5 *
Renewable ground water	4.8	7.5
Agricultural drainage water	4.5	8.4
Treated domestic waste water	0.7	2.5
Treated industrial waste water	6.7	6.7
Desert aquifers	0.57	3.77
Rainfall and flush harvesting	-	1.5
Saving from management	-	1.5
Total	72.77	89.37

* Including the 2 BCM possible yields from Jonglei project. Jonglei project in Sudan intended to increase availability from Nile water reducing the evaporation from Sudan's Sudd swamps. Project has not been completed due to conflict in the region.

Source: (UN CCA,2001)

For the year 2017, water demand is expected to rise up to 87.9 BCM. The rapid growth of demand is planned to be partly supplied with additional water resources that can be obtained from non-renewable groundwater aquifers in the Sinai and the Eastern and Western deserts (UN CCA, 2001).

As mentioned in Table 1, the water balance for the year 2017 can meet the demand if the Irrigation Improvement Plan, Drainage Water Reuse, Treated Wastewater Reuse achieve the target figures. The objectives need some consideration regarding their implementation. This specifically refers to the prolonged conflict around Jonglei project in Sudan leaving little hopes for its termination or drainage water reuse that already amounted to 4.7 BCM in 1990 and to 8.5 in 2007.

B. Land expansion

Expected considerable incremental increase in demand occurs in agricultural and industry sectors (Abu- Zeid, 1991) due to further development of manufacturing sector and land reclamation projects. Annual 2.1 percent population growth rate obliges the agriculture sector to provide food for a larger number of people and this under conditions of continuously declining per capita crop area and per capita crop production (MWRI, 2002). The difficulties in relation to limited land resources are not restricted to the problem of food security but it is linked to the employment issue as well. The rural area is accommodating 57 percent of the population, 50 percent of which is involved in the agricultural sector (UNDP, 2003). The food and habitat requirements and increasing demand on job push the government to the horizontal land expansion plans. The last has been considered as a solution for the absorption of population growth and job generation. The Plans promise to add 3.4 million feddans of desert land to the cultivated land area (UN CCA, 2001). The land expansion projects intend to reclaim almost 44 percent of present cultivated land area by transferring the water to the desert lands. This means that, at the present water use practices, land expansion would place an enormous strain on water supply.

4. Economic forces

As supplies fail to catch up the growing demand, competition for water will increase to the benefit of domestic water users and at the expense of agriculture.

Table 2 illustrates the present water distribution among different economic sectors. Agriculture is the largest consumer of water resources worldwide and in Egypt as well. The annual freshwater withdrawals for agriculture in 2001 amounted to 83 percent (UN CCA, 2001). In spite of its high water consumption levels, its contribution to GDP accounts only for 16.5 percent compared to industrial and service sectors with 33.3 and 50.2 percent share in GDP respectively (Malashkhia, 2003). As some analysis pointed out, agriculture can be affected by increasing water scarcity due to growing demands from other sectors. It has to compete with high value users; this in the long run would lead to release of water from agriculture to the other sectors (Engelbert *et al.*, 1984). The consideration about water reallocation becomes relevant taking into account Egyptian government's support to the development of industrial sector (MWRI, 2002).

Table 2. Water allocation among water users.

Water Users	Worldwide		Egypt	
	(%)		(%)	
	1999	1990	2001	
Agriculture	65	84	83	78*
Industry	25	7.8	10	14*
Domestic use	10	5.2	6	8*
Total water use in BCM	-	59.2	67.47	68.67*

Source: Abu-Zeid, 1991, UN CCA, 2001 and *FAO Aquastat

5. Political forces (Irrigation water subsidies)

Water is a critical component of development in Egypt. However, limited water resources are not treated as a scarce commodity; on the contrary, it is heavily subsidized by the Egyptian government which unintentionally promotes wasteful practices and hinders the emergence of rational use of resources (Ahmad, 2002). Issue of subsidy involves many factors and its removal would have widespread effects on the whole society.

The domestic use of water shows the inefficiency of water distribution system in 1991 that reached 50 percent (Abu-Zeid, 1991). It is much the same even after 10 years. At present, the leakages in the system including illegal connections and other leakages are estimated at the same rate of 50 percent and in some cases they reach even 70 percent (Malashkhia, 2003). This situation in distribution schemes is partly generated by lack of funds for improving the operation and maintenance of the whole system which itself derives from the low cost recovery. The real cost of drinking water in Cairo is 0.65 LE per cubic meter and it is sold at 0.35 LE to the households. The commercial sector is subsidized as well. However, only half of the real water cost is recovered from the small workshops. On the other hand, large factories pay 0.50 LE per cubic meter of clean water. Collection efficiency is another issue that is characterized by the fact that 25 percent of all factories in Cairo do not pay the cost for water delivery (Malashkhia, 2003).

III – Demand-Oriented Measures for Water Conservation

Demand management tries to reduce and control water demands, as well as improve overall water use efficiency. Demand management allocates available water to competing user groups according to the needs. Water is often considered a free good in many countries where a supply

oriented approach attempts to serve water in quantities, relying on the assumption that the user will make proper use of it. This has been the case in Egypt for several decades.

However, such a surplus-biased system wastes considerable amounts of water, since the precious resource is then taken for granted and no effort is made to conserve it. In contrast, a demand oriented approach assesses the real demand for water and tries to urge the users to conserve water and make better use of it (Bassiouni, 2003).

Demand-oriented measures that can be implemented in Egypt include the following:

1. Shifting to less water-demanding crops. For instance, introducing cropping patterns with low water requirements (i.e. abandoning rice and sugarcanes for other cropping patterns).
2. Improving the efficiency of the existing public water supply system by reducing losses, detecting leakage and improving irrigation distribution and conveyance efficiency. Inefficient water systems are a major source of water loss. In the developing world, in many cities, faulty pipes and illegal connections waste between 20 to 50 percent of public water supplies. In Egypt, the current losses in the distribution system are considered too high. Water conservation measures need to be implemented and practiced by all water users and unnecessary or wasteful uses need to be reduced or eliminated where possible. A sound, reasonable, and effective water conservation culture can make the difference between adequate supplies and shortages.
3. Introducing the implementation of financial measures for water conservation which might include various kinds of land or crop taxes, production charges, water pricing, or subsidies for water conservation. Moreover, water is usually priced much lower than the actual cost of securing, treating, and distributing it, leaving little incentive for households and industries to conserve water. Letting users pay for water or making it more expensive by paying the costs to treat and deliver water will awaken to the awareness about the scarcity of the resource. For, water scarcity is closely linked to water use; thus, the cost of water should be made higher. We must finally shift to viewing water as an economic commodity, as we already do with electricity. While there are possible alternative energy sources for the future, the only alternative to water is water.
4. Finally, introducing public awareness campaigns aimed towards advocating a new water culture in a society based on the principle of conservation. The significance of water conservation in irrigation and domestic uses can be promoted through such public awareness campaigns.

IV – Rational water use

1. Water saving techniques

A number of measures have been taken towards the rational use of water for different activities. Some of these measures have been applied to domestic water systems and industrial requirement. However, agriculture being the major consumer of water has the lion share of these measures. Following are the measures applied to agriculture among a complete package of water saving techniques (El Quosy, 2005):

A. Use of modern irrigation systems in newly reclaimed land

It is obligatory to use sprinkler and drip irrigation systems in the desert lands converted into agricultural production through reclamation. Gravity or flood irrigation in these areas is prohibited by law. This is obvious because of the high permeability of these soils and their high capacity of natural drainage.

B. The change from surface irrigation to drip irrigation in the orchards and vegetable farms in the old lands

Some 700,000 feddans in the old lands of the Nile Valley and Delta are occupied with different types of fruit trees, citrus and grape yards in addition to the area cultivated with summer and winter vegetables. This area is currently irrigated traditionally with surface irrigation. It is the plan of the country to change the irrigation system in these areas into drip irrigation. The cost of the irrigation system and the running cost of operation are expected to be borne jointly by the farmers and the state.

C. Land leveling

Field experiments proved that precise land leveling has a positive impact on the reduction of water supply since it reduces surface run-off to a minimum. Special attention is always paid to the major water consuming crops like sugar cane and rice.

D. Night irrigation

Farmers are encouraged to practice night irrigation since it reduces evaporation losses if irrigation is carried out during day time, in addition to the reduction of tail end losses taking place directly from irrigation to drainage canals if fresh water is not abstracted at night. It is worth mentioning that the Egyptian irrigation network is designed for 24 hours a day abstraction, i.e. there is no storage capacity in the system.

E. Modification of the cropping pattern

The cropping pattern in Egypt is governed by a number of factors which include: the country's need for food and natural fiber, the export requirement, the availability of land and water, the employment needs, the climatic conditions, status of soil salinity,...etc. It is always the desire of the officials to bring the agricultural water requirements to a minimum in order to make sufficient quantities available for other activities that might be of higher priority (such as drinking water supply) or of higher return per unit volume of water (such as industry or tourism). For this reason, the area of sugar cane is kept constant while sugar beet is increasing. The area cultivated with rice is limited to about one million feddans. The deviation from these two rules causes farmers to be heavily penalized by the law.

F. Introduction of short-age varieties

Another way of encouraging water savings in agriculture is to raise crops which stay a shorter period in the fields by reducing their growing age. A good example is represented by the short-age varieties of rice which stay in the field only 150 days compared with the traditional variety that need 180-210 days. The reduction in the number of days is immediately reflected on the number of irrigation gifts and consequently on the quantity of water supplied. Other examples are wheat, maize, cotton and legumes.

G. Irrigation improvement projects in the old lands

The alluvial soils of the Nile Valley and Delta reduce the possibility of changing the existing gravity irrigation into modern systems. The reason for this is:

- the very low permeability of the soils and the high possibility of soil salinization;
- the high initial cost of the imported material (sprinklers, drippers, filters, fertilizers,...etc) and the high cost of energy, maintenance and spare parts;
- the need for skilled labor which might not be available in rural areas while there is ample number of laborers acquainted with surface irrigation systems;

- the need to raise crops of relatively low return like wheat and maize. Other cash crops like vegetables and flowers are not easily marketed in the surrounding area.

For these reasons, the state has supported the improvement of surface irrigation in the old lands. A number of water and energy saving techniques are implemented through the Irrigation Improvement Projects (IIP). Some of these techniques are:

- a. The change from the earth field ditches named Misqas into canals or pipelines. This change reduces seepage, aquatic weeds and evaporation from free water surface due to the reduction of the area of this surface;
- b. The change from multi point abstraction of water from the mesqa into one point lift on the top end of a raised mesqa.

This is necessary for better steady and uniform mesqa flow plus the saving in energy needed to operate the lifting pumps. One of the major advantages of the above concept is the setting up of water users' associations on the mesqas which will be followed by the formation of water federations on the supply canals. This concept strengthens the idea of users' participation in the management of the system at its low level which relieves the government agencies from such obligations giving them the opportunity to have better management of other higher level activities.

- c. The change from upstream control into downstream control.

The distribution system in Egypt, as mentioned earlier, is based upon upstream control. The Irrigation Improvement Project has introduced downstream control at the level of the supply canals as one of the measures that initiate demand management.

The traditional head regulators operated manually or mechanically on the basis of upstream control are replaced by regulators equipped with automatic gates capable of providing the required flow when demand is in progress, reduced flow when demand decreases and complete shut off when demand is stopped. In the mean time this type of system allows for a storage build-up during periods of no abstraction to permit heavy abstraction afterwards.

2. Optimum use of resources

A. Reuse of drainage water and treated wastewater

Egypt is one of the pioneer countries in the reuse of water. This process started as early as the 1920's and the water multiplier now stands at 150-200%. All drainage water of the Upper Egypt returns back to the River Nile raising its salinity from about 200 ppm at Aswan to less than 300 ppm near Cairo. Four more billion cubic meters of drainage water generated in the southern part of the Delta are mixed with fresh water and reused for different purposes. It is the plan of the country to reuse another three billion cubic meter per year for the irrigation of Al Salam Canal Project (620,000 feddans or 250,000 hectares) and for the feeding of Nubaria Canal (one of the largest irrigation canals in the Western Delta which serve an area of more than seven hundred thousand feddans of newly reclaimed lands.), the canal will be fed with one billion cubic meter of drainage water from Omoum Drain (El Quosy, 2005).

At present, treated sewage and industrial effluent can supply about seven million cubic meters per day or about two billion cubic meters per year. Plans to use this water for the cultivation of special crops (timber trees, industrial crops such as cotton, flax, flowers,...etc.) are under preparation.

B. Desalination of brackish and sea water

Desalination has long been confined to situations where no other alternatives were available to produce drinking water (some coastal towns, islands, remote industrial sites), or where energy was abundantly available (power stations, gas and oil production fields). Today, desalination is becoming a serious option for the production of drinking- and industrial water as an alternative to traditional surface water treatment and long distance conveyance. The desalination capacity in Egypt has grown to some 150,000 m³/day. Most of the plants treat seawater, but a growing number of installations use brackish water. The capacity of individual plants is generally small and ranges between 500 and 10,000 m³/day (MWRI, 2005).

There is unlimited potential for further development of seawater desalination in Egypt along the long shoreline. Sectors of application are the tourist sector and the industries along the coast. Considering the vast reserves of brackish groundwater in Egypt, there is also great potential for brackish water desalination which can be applied at much lower cost. Desalination of inland brackish groundwater requires special attention for the discharge of the brine (the highly saline by-product of desalination). Treatment of domestic waste water and of drainage water is a potential new field of application for which vast quantities of water are available in Egypt.

C. Importance of international co-operation

The international aspect is a crucial factor in Egyptian water policy. Because Egypt's water resources are all produced outside the country (upstream of Lake Nasser), the planned expansion of supply has to be undertaken in collaboration with upstream governments. This places Egypt in a very difficult planning situation, since it simply does not possess control over the speed of the implementation of the water conservation projects along the White Nile. It is estimated that the inflow to Lake Nasser could be increased by as much as 18 billion m³ per year to be shared by Egypt and Sudan by implementing the four phases of the upper Nile projects (Jonglei I, Jonglei II, Machar Marshes and Bahr El-Ghazal). And, as it looks now, Egypt will increasingly come to rely on the implementation of these projects (Hivdt, 2000).

D. Nile Basin Initiative (NBI) projects

The NBI intervention seeks to build confidence and capacity across the basin through a shared vision program (SVP), and to initiate concrete investment and action on the ground through a subsidiary action program (SAP). The NBI plans to implement projects, in partnership with member states that will contribute to strengthening the cooperation mechanism and to long-term sustainable development, economic growth and regional integration (Sileet *et al.*, 2007).

The SVP contributes to the creation of an enabling environment for investments and action on the ground and will promote the shared vision through a set of effective basin-wide activities. An initial set of basin-wide SVP projects has been endorsed by Nile-COM. They include: environmental action, power trade, efficient water use for agriculture, water resources planning and management, coordination, applied training, and socio-economic development and benefit sharing. Following are the SVP projects contributing to water efficiency, integrated water resources management (IWRM), confidence building and awareness and their objectives and expected impacts:

Nile Trans-boundary Environmental Action Project (NTEAP) with its five components (Institutional strengthening, community level land, forest & water conservation, environmental education and public awareness, wetlands and biodiversity conservation, and basin-wide water quality monitoring) aims to provide a strategic framework for environmentally sustainable development and to support basin wide environmental action. The water quality monitoring component contributes to the enhancement of water quality in Nile Basin Countries.

Water Resources Planning and Management (WRPM) project has four components: water policy good practice guides and support, project planning & management good practice guides, Nile Basin

decision support system, and regional coordination & facilitation. These components contribute to achieving the project's goals in enhancing analytical capacity for basin wide perspective to support the development, management and protection of Nile Basin water resources in an equitable, optimal and sustainable manner.

Efficient Water Use for Agricultural Production (EWUAP) project with its four components (water harvesting, community managed irrigation, public and private managed irrigation and project coordination & facilitation) aims to establish a forum to assist stakeholders to address issues related to efficient use of water for agricultural production in the Nile Basin, and to provide an opportunity to develop a sound conceptual and practical basis for Nile Riparian countries to increase the availability and efficient use of water for agricultural production.

Some of the SVPs have an indirect impact and contribution in the IWRM in the Nile Basin through strengthening the capacity for practitioners and post graduates in subjects of water resources planning and management in public and private sectors (Applied Training project), developing confidence in regional cooperation at both Basin and local levels (Confidence Building and Stakeholder Involvement project) and enhancing the process of integration and cooperation to further socio economic development in the Nile Basin (Socio economic Development and Benefit Sharing).

SAPs plan and implement action on the ground at the lowest appropriate level. They comprise actual development projects at sub-basin level, in order to address the challenges of regional co-operation and development opportunities with trans-boundary implications. Two groups of countries have been formed to investigate the development of investment projects on the Nile Basin. These are the Eastern Nile Group (ENSAP), which includes Egypt, Sudan and Ethiopia; and the Nile Equatorial Lakes Group (NELSAP) comprising Uganda, Tanzania, Kenya, Rwanda, Burundi and the Democratic Republic of Congo and Egypt.

E. ENSAP relevant projects can be described as follows

Integrated Watershed Management: Obvious regional benefits of this project will be erosion control leading to decreased siltation and sedimentation in downstream river/reservoir reaches, which will increase reservoir life, improve hydropower production and irrigation efficiency, leading to an overall increase in land productivity, which will yield higher agricultural outputs, and thus enhance food security and alleviate poverty.

Baro-Akobo-Sobat Multipurpose: The project may offer opportunities for win-win multipurpose development. Important water conservation gains may be possible through improved water management, storage and flood routine.

F. Eastern Nile Planning Model

An Eastern Nile Planning Model (ENPM) has been proposed as a common analytical basis for identifying, and assessing options, quantifying benefits and impacts, evaluating tradeoffs, and analyzing and managing information to support complex decision making processes on the Eastern Nile.

Flood preparedness and Early Warning: Climate and river flows in the Eastern Nile of water (EN) are highly variable. The region is thus prone to extremes of droughts and floods. While there is some flood warning activity in individual countries, there is no integrated or cooperative flood warning system for the Eastern Nile basin.

Irrigation and Drainage: Among other factors, unpredictable seasonal and spatial distribution rainfall in some regions is a factor contributing to low agricultural productivity. The development of irrigation and intensification of existing agricultures offer the potential to increase food security, enhance agricultural productivity and improve livelihoods. The regional benefits of this project are

expected to be maximized through the integrated development of different components, as well as building different sub-projects under the integrated development of the Eastern Nile Project.

Eastern Nile Joint Multipurpose Program: Integrated and joint basin management offers the greatest opportunity to unlock economic growth, promote regional integration, and realize peace and stability. Investments in new storage capacity and improvising watershed management have the potential to improve irrigation and agricultural productivity in all countries by reducing sedimentation in reservoirs, mitigating drought impact and flood damage, and supplying substantial hydropower electricity to meet rapidly expanding demand.

G. NELSAP project

The Regional Agricultural Program will promote opportunities for cooperation in the Nile Basin through private investment, public- private partnerships and enhanced trade, in the field of high value crops and products. It will also identify steps to increase food security through increased investment, income generation and pro-poor growth.

3. Development of national water resources plan for Egypt 2017

The Egyptian governmental institution represented by MWRI has developed what is called a National Water Resources Plan (NWRP) to support the country's development until the year 2017. Specifically, NWRP has three major pillars:

- Increasing water use efficiency;
- Water quality protection;
- Pollution control and water supply augmentation.

NWRP is based on a strategy that has been called 'Facing the Challenge' (FtC). FtC includes measures to develop additional resources, make better use of existing resources, and measures in the field of water quality and environmental protection.

Improving the performance of the water resources system. More water will be available for the various uses and the water quality will improve significantly. The agricultural area will increase by 35% as a result of horizontal expansion and of the two mega projects in Toshka and Sinai. Space for living will be created in the desert for more than 20% of the population as a result of these projects. The implementation of the strategy will support the socio-economic development of the country and provide safe drinking water to its population. The access of the population to safe sanitation facilities will double from the present 30% to 60%. Summarizing and as stated in the objectives, the strategy will safeguard the water supply up to the year 2017.

The FtC strategy follows an integrated approach to cope with the increasing pressure on the water resources system in Egypt and contains a wide range of measures and policy changes up to the year 2017. The implementation of this strategy is a real challenge. Further development of the system after 2017 may require some drastic policy decisions at the national level, e.g. accepting some limitations in growth of the agricultural sector and increasing the developments and corresponding employment in the industrial and services sectors. An increase in the Nile water supply will ease the situation somewhat and should be pursued. A limited increase is not unrealistic, either as a result of water conservation projects in Sudan, changes in reservoir operation of Lake Nasser or (in the very long run) as a result of climate change.

The integrated approach of FtC assumes that all measures are really implemented. Failure to implement some measures may have severe consequences for the overall strategy. This is in particular the case for the expected improvement of the water quality. An insufficient improvement of the water quality will mean that the increase in the reuse of water will be much less than

expected with the consequence that there will be less water available for agriculture, leading to less water available per feddan and a further lowering of cropping intensities.

4. Legislation

New implementation concepts need laws and regulations updates. Generally, water laws in Egypt are as old as the country itself. They were never static, they always have dynamic nature. However, at this stage of history, when demand is pressing supply heavily, a need for strict laws is probably more than any previous time. A new water law is being developed at the present time. This law puts more emphasis on four important points:

- Increased penalties for water miss-users or those who cause waste in different fields;
- Strengthening of “Polluter Pay” principal;
- Encouragement of participation both at the low level through water users associations in old and new lands as well as at the higher level of supply canal through the setting up of water federations;
- Introduction of water extension services represented by the Irrigation Advisory Services “IAS” which provide farmers with the advice they need for a better and rational use of irrigation water. Other users, such as for domestic supply, are made aware by publicity through different media (newspapers, radio, television,...).

5. Institutional reform

Egypt as one of the oldest country in the world practicing river-fed agriculture depends on a strong central organization working on conveyance and distribution of water. All these agencies should change from the old regime of complete government control to the new concept of users’ participation.

In the meantime, the vital approach and concept of integrated water resources management should also be part of this reform. This means that separate entities such as irrigation, drainage, structures, survey, mechanical and electrical divisions are no longer acceptable and even separation between water, soil, crop, and climate is not the correct way of management. It is the opinion of the officials in Egypt now to create an irrigation district which includes all the above disciplines and practice real integrated water management.

6. Participatory irrigation management (PIM)

One of the fundamentals of increasing water use efficiency is the involvement of all stakeholders as much as possible in the various management activities and levels. As water is essential to all forms of life and prosperity, competition for water among users is already escalating as growing needs outstrip the limited resources. The objective should be to transform the competition between stakeholders into a form of cooperation that achieves the highest overall revenue with the least sectoral harm. Private stakeholders associations can provide a counterweight to the government departments own technical agencies to enhance water use efficiency. Most of the developed countries adopted PIM policies some time ago, as a matter of fiscal necessity. Farmers in developed countries enjoy high levels of education, and strong support services through both the private market and the public sector.

7. National water quality monitoring program

Water quality deterioration is one of the most contributed factors in water losses in Egypt. Egypt releases 12.5 BCM per year of drainage water to the Mediterranean Sea because of its unsuitable quality (MWRI, 2005). The National Water Quality Monitoring Program has been launched based

on the integrated approach for water resources management. It was developed by the National Water Research Center to serve as the solid scientific foundation for Egypt's policy development and decision making. The main objectives of this program are covering Egypt with water quality network to assess decisions of water use, to enhance the human resources capacity building and to unify the standards.

8. Role of the private sector and privatization

There is always a mix between privatization and the role of the private sector in irrigation. Although irrigation in Egypt is practiced through a strict central governmental authorities, the private sector is heavily involved in the provision of services such as construction (through private as well as public sector contractors), engineering consultants, selling irrigation equipment, management of large-scale modern irrigation systems, drilling of groundwater wells,.....etc. Privatization of the irrigation system in Egypt has already started by the establishment of water users associations and water federations.

The following step would be the establishment of management boards capable of conveying and distributing water from one end of the system to the fields. This type of service provider will be in place in the very near future as soon as government agencies give green light by contracting complete commands to water boards. It is not necessary that water boards be responsible for large or small areas. The exercise may start with very small areas and grow up with time and experience.

V – Conclusion

This paper has cast light on the rational water use in Egypt. It represents an attempt to collect the scattered and fragmented knowledge about the subject in order to highlight the major characteristics of the planning process. Egyptian water resource planning is given the task of satisfying the ever-increasing water demands which are dictated by a rapidly growing population, increased urbanization, higher standards of living, and an agricultural policy which emphasizes expanded production in order to feed the growing population. There is, and probably always will be, enough water to satisfy municipal and industrial water use.

From the analysis of water resource planning in Egypt, the planning emphasis can be characterized by the following eight points: (1) a shift from water abundance to water deficit; (2) the importance of international co-operation; (3) supply bias; (4) environmental concern; (5) lack of data; (6) established priority to non-agricultural uses of water; (7) delayed implementation; and (8) the establishment of an administrative framework for water resource planning.

Thirst for water will become one of the most pressing resource issues of the 21st Century. Egypt water consumption is rising and continues to grow rapidly. The scope and extent of water conservation is decisively shaped by the shift to a demand-oriented water management strategy in other words a demand-managed water culture. Such a policy is imperative for Egypt and for other arid countries facing similar water constraints.

The agricultural sector is considered as critical for tackling poverty in developing countries. Egypt is not an exception as its large population is engaged in agricultural activities. In the future, irrigation water, which is the absolutely crucial part of Egypt's agriculture, has to satisfy demands of even larger population and increasing living standards. Till now, the water shortages have been tackled by increasing extractions of resources and developing new supply options for the irrigation system. However, most of the supply options are already exhausted and cannot maintain significant enlargements. Some improvements can be achieved through efficiency increase. The demand side management entails some potential for water saving which might be possible through cost recovery as one of the financial instruments for water conservation.

The main objections raised by efficiency and cost recovery measures are negative social effects and environmental implications. Without building favorable preconditions for cost recovery, the introduction of user charge at this stage might face inevitable problems. Preconditions imply community involvement in canal management, well-defined rights, responsibilities for quota violations in case of drainage water reuse and rice cultivation. Whatever conservation measure will be applied, the main problem for the environment will remain the same. Soil salinization due to drainage water reuse or reduced water applications on fields will be a threat. Balanced approach in pricing and adequate knowledge of the soil salinity itself can ease the task. This would mean intensive awareness campaigns enriching farmer's information about salinity management, spreading the information about new water-saving and salinity resistant crops. Water scarcity is not an easy issue to deal with but still there are hopes that its negative effects can be minimized. To this end, an inclusive picture of the problems with all the factors involved has to be realized. In this study, an attempt has been made to view just some aspects of the whole picture. However, for a further understanding of the issue, other factors need to be added, which might be the subject for future study.

Egypt water resource planning is facing a number of problems - such as the lack of funds and non-rational governance - which predominate in less-developed economies. Establishing a planning system, in general, is expensive; therefore, it is developed only if needed. Egypt in fact might have had too much water at one time, a surplus which has severely hindered the necessity to implement a planning system. Emphasis on water resource planning depends on the scarcity of the resource. The greater the scarcity, the more planning is needed to counteract it. According to that argument, Egypt is expected to strengthen its water resource planning capability in the near future, following a greater scarcity of its water supply (Hvidt, 2000) .

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⁽¹⁾ The poverty line used in HDR 2003 for rural area is 3963 LE (Egyptian Pound). Poor is a person whose expenditure capacity is lower than the specified poverty line. Those who are below food poverty line (3752.6 LE) are considered as ultra poor.