Overview of water resources and requirements in Egypt; the factors controlling its management and development

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Summary

Egypt covers very arid regions situated between the Sahara and Arabian deserts. It is extremely dependant on the River Nile as the country hardly has any other fresh water resources. Rainfall is very rare, except for a very small trip along the coast of the Mediterranean. Fossil groundwater is available in parts of the Western and Eastern Deserts and Sinai. The main groundwater aquifers in Egypt are generally formed in course clastic rocks (sand and gravels) and in fissured and karstified rocks (igneous and metamorphic rocks as well as limestone).

Egypt's municipal, agricultural and industrial water requirements increase with time due to the increase in population and the improvement of living standards. In order to relieve the population pressure, there is an ambitious programme to increase the inhabited area in Egypt from the present 5.5% (mostly in the Nile Valley and the Delta) to about 25% through the land reclamation schemes and encourage industrialization in new areas outside the valley and its delta. Thus, to fulfill the water requirements for the country, the integrated management and development plan has to be implemented.

The most important factors controlling the development of the Egyptian water resources to meet expected demands are: 1) The excepted population growth; 2) The attitude of farmers and other population sectors; 3) The institutional scheme of water irrigation use; 4) Employment generation and development policies; 5) Land resources; 6) The land tenure system; 7) The cropping pattern; 8) The policy of the food security and 9) The cost of water and its recovery. The research article also highlights the environmental problems that related to the water resources in Egypt including water pollution and climatic changes an the drop in groundwater levels due to the over pumping in some areas and water logging due to the unsuitable irrigation system in other areas.

Key words: Water management, Egypt, Groundwater, Water resources.

Introduction

The growing population of Egypt and related industrial and agricultural activities has increased the demand for water to a level that reaches the limits of the available supply. Although, water resources are of great economic significance for the population in Egypt, it is an important raw material for agriculture and industry and other sectors in the economy. Water resources play a very important role with regard to social objective. In fact, water resources are of importance in increasing employment in all sectors of society and to create an acceptable distribution of the national income.

Egypt covers an area of 1,000,518 km^2, and lies within the arid belt of North Africa and southwest Asia. In Egypt, the continues increase in population and subsequent increase in the demand for fresh water (in agriculture, industrial, mining activities, etc ….), is causing a continuous decrease in per capita quota (Abu-Zied, 1998). At present the per capita quote of Egypt is estimated as 922 m^3. Table (1) shows the distribution of water resources according to the water sources and the uses.

As shown in table (1), Egypt is extremely dependant on the River Nile, being the most down stream country in the Nile basin. This makes co-operation with other Nile basin countries indispensable. At the same time the country hardly has any other fresh water resources. Rainfall is very rare, except for a very small strip along the coast of the Mediterranean. Fossil groundwater is available in parts of the Western and Eastern Deserts and Sinai.

Table (1) Water availability and water demand for Egypt (2003/2004**)**

Water sources	Volume BCM	%	Water usage	Volume	%
Nile water	55.5	76.6	Agricultural demand	57.8	80
Groundwater extraction	6.10	8.4	Industrial demands	7.5	13.3
Non- conventional sources	9	12.4	Municipal water usage	4.7	6.4
Desalinization	0.3	0.4	Navigation	2.1	2.9
Rain	1.14	1.6	Other usage	0.4	0.55
TOTAL	72.04	100	Total	72.5	100

There are many water-related challenges facing Egypt. The most important challenge of them is the population growth; from 59 million in 2000 to 83 million in 2017 (MWRI 2002) and related water demand for public water supply and economic activities, in particular agriculture. In the present, the population of Egypt lives only at 5 % of the total surface area of Egypt (mainly the river valley and delta). To relieve the population pressure in the Nile valley and Delta, the government has embarked on an ambitious programme to increase the inhabited area in Egypt from the present 5.5 % to about 25 %.

It is obvious that the demand for water resource will increase. Industrial growth, the need to feed the growing population and hence, a growth demand for water resulted from agriculture horizontal expansion in the desert area, etc, cause a growing demand for water resources. At the same time the available fresh water resources are expected to remain more or less the same. This to make more efficient use of present resources and, if possible to develop additional water resources.

Also, the increase in population and industrial and agriculture activities has resulted in a rapid deterioration of water resources, in particular in the Nile Delta. This low water quality threatens public health, reduces its use for economic activities and damages the natural ecology of the water system. Massive expenditure is needed to reduce the population loads and to provide the population with adequate drinking water and sanitary facilities.

It has become clear that the above issue can only solved if the institutional setting of water management is improved. This includes aspects of co- operation, decentralization and privatization. Major elements in this respect are a participatory approach and the inclusion cost-recovery aspects of water resources. Ministry of Water Resources and Irrigation (MWRI) has already embarked upon a major programme of reform, among others by setting up of water boards and transferring water management tasks to them.

Because population growth, industrial growth and development the outside old lands (horizontal expansion in the Nile fringes and desert area) and development of new industrial cities in desert areas, the demand for water of good quality increasing. Since the potential for development of new water resources is limited (mainly limited to groundwater development in the Western Desert) water is becoming an increasingly scarce commodity. This urges a more efficient use of water. It also urges alteration for the sustainability of the water resources system in areas where this resource is not replenished.

At present, Egypt's water recourses can be categorized into (a) precipitations and rain fall (b) surface water from the Nile River and (c) Groundwater from the major groundwater aquifers. Evaluation of these water resources is given in considerable detail focusing on the potential for possibility of developing such resources. The article is highlighting future water requirements of the Egypt and the main factors controlling its management and development.

1. Available water resources for Egypt

1.1. Precipitation

Rainfall in Egypt is very limited with respect to its geographical and temporary distribution. The total amount of rainfall on Egyptian territories is about 15 x 10^9 m^3 /year. Only 2.85 % m^3/year of this quantity is recharging groundwater aquifer systems (EEAA 2001).

The total amount of rainfall on the northern cost of Egypt is 2.5 x 10^9 m^3/year with average annual precipitation rate seldom exceeds 150 mm/year. However it is enough for planting a number of crops on a seasonal base and also growing grasses for cheeps and goats grazing.

On the other hand, flash floods occurring due to short-period heavy storms are considered a source of environmental damage especially in the Red Sea area and Southern Sinai. This water could be directly used to meet part of the water requirements or it could be used to recharge the shallow groundwater aquifers. It is estimated that about 1 BCM of water on average can be utilized annually by harvesting flash floods (ENCID, 1996).

1.2. The Nile River

The average annual yield of the Nile River is estimated at 84 BCM at Aswan. The discharge of the Nile River is subject to wide seasonal variation. The annual river flow can be divided into two periods: 1) A short 3-month long high muddy flow season, and 2) A longer 9-month long flow clear flow season. According to the 1959 Agreement with Sudan, Egypt's annual share of the river water is determined by 55.5 BCM. The agreement also allocated 18.5 BCM for Sudan. It is important to mention that currently the total managed water on the river Nile basin represents only about 5 % of the total water on the catchments area of the basin.

Downstream HAD, the Nile water is diverted from the main stream into an intensive network of irrigation canals, the main function of these canals is to provide water for agricultural use. The agriculture drainage water is then collected through a network of tile and open drains. In Upper Egypt, most of the collected drainage water flows back to the Nile as return flow, while in the Delta, drainage water is pumped into the Mediterranean and the northern lake.

In a long-term perspective, an additional amount of 4.8 BCM of fresh water per year will be gained if the planned projects in the Upper Nile are implemented (e.g Jonglei Canal).

1.3. Desalination of water

Desalinization in Egypt started some 20 years ago for additional drinking water supply to coastal towns and in the petroleum sector and the energy sector (power station). In Egypt, desalinization of sea water has been given low priority as a water resource because the cost of treatment is high compared with other sources. Desalination is actually practiced where there is no other alternatives were available (Red Sea tourism villages and resorts, islands, remote industrial sites) where the economic value of the water is high enough to cover the treatment costs. Due to the developments in desalination techniques and the reduction of cost price, the application for fresh water production have sharply increased and will become even a more competitive option in the future (Allam et al., 2002).

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. In Egypt, the increased use of desalination is noticeable, where the total installed capacity has grown to some 150,000 m^3/year (Allam et al. 2002). Considering the fact that Egypt has about 2,080 km of shoreline along both the Red Sea and the Mediterranean Sea, desalination can be used as sustainable water sources for domestic water in many localities. If solar and wind energy can be utilized as sources of power, desalinization can become economic for other uses.

Desalination of the brackish groundwater has been receiving a considerably little attention considering the availability of the brackish groundwater aquifers. This area may need more attention in the future to provide an addition water supply sources. This will depends on the development of the reasonable low cost technology. Currently the most common techniques for desalination in Egypt are the multi-stage flash evaporation (MSF) and the reversed osmosis (RO). The second is most appropriate for brackish groundwater and therefore most of the touristic resorts in the Red Sea coast, and South Sinai depend on such techniques for provided the potable water.

1.4. Non-conventional sources of water

Non-conventional sources include other sources of water that can be used to meet part of the water requirement. These sources are called the Non-conventional sources and include~~s~~; the renewable groundwater aquifer underlying the Nile Valley and Delta, the reuse of agricultural drainage water, and the reuse of treated sewage water. These water sources cannot be considered independent resources and therefore, cannot be added to Egypt's fresh water resources. In fact, using these sources is a recycling process of the previously used Nile fresh water in such a way that improves the overall efficiency of the water distribution system.

1.5. Groundwater Resources

Groundwater aquifers in Egypt are generally formed in coarse clastic rocks (sand and gravels) and in fissured and karstified rocks (limestone, and hard rocks). These aquifers can be differentiated into two main categories; the first compresses the renewable aquifers that include the groundwater in the Nile Valley and the Delta aquifer system, while the second category is the non-renewable aquifers that include a list of aquifers. According to the ages and the potentiality, the groundwater aquifers in Egypt could be divided into; a Quaternary aquifer (Nile aquifer system), 1.6. Pliocene aquifer 1.7. The Miocene Aquifer (Moghra aquifer), 1.8. The karstified Carbonate Aquifer 1.9. The Nubian Sandstone Aquifer and 1.10. The Fractured Basement Aquifer. A brief description of the lithological and hydrogeological characteristics of these aquifers as well as their main recharging sources is given below. Fig (1) shows the distribution of theses aquifers.

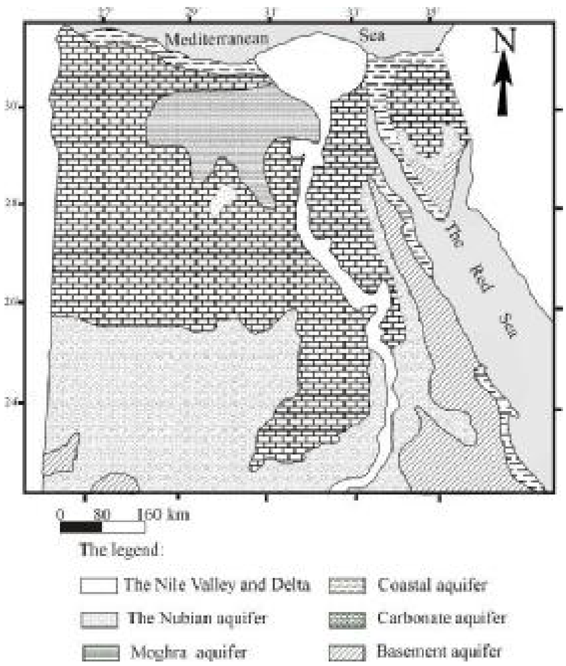

Fig. (1): The groundwater aquifers in Egypt

1.5.1. The Quaternary Aquifer System

The quaternary aquifer system in Egypt has a wide distribution, includes most of coarse clastic rocks aquifers (sand and gravel). It occupies the Nile Valley, Nile Delta, Mediterranean costal zone and deltaic areas of the main wadis in desert areas (Fig. 1). The Quaternary section in the Nile Valley is composed of the Plio-Pleistocene sand and gravel with intercalation of clay lenses (Fig.

2). The thickness of the aquifer decrease from 300 meter at Sohag to a few tens of meters in the north near Cairo and also in the south near Aswan. The thickness of the upper clay layer varies between 15 and 20 m with an average 12 meters (Abdel Monein 1992, 1999, Attia 1985). The reservoir contains large resources of water amounting 400 x 10^3 million cubic meter (Hefney 1986). It is recharged by the infiltration from irrigation system at the rate of about 3 x 10^3 million cubic meter per year (Hashim 1963). The fringes are recharged by infiltration water from valleys during torrent periods or from upward movement of groundwater from Nubian aquifer in the southern area of the Nile valley (Hemdan, 1999). The aquifer discharge is through seepage to the Nile River (about 1.6 x 10^3 million cubic meters per year) and the extraction through the productive wells (about 1 x 10^3 million cubic meters per year).

In the Nile Delta, the aquifer consists mainly of sand and gravel with occasional thin clay intercalations. The sands and gravels are more frequent in the southern and middle parts while clay is dominant in the north with occasional discontinuity and intercalation of sand and gravel (Fig.3). Alternating clays and sand with gravel which present especially in the northeast parts reflect the Delta pro-gradation cyclicity sequence. The thickness of these sediments gradually increases towards the north and northeast. It ranges between 100-400 m in the southern part, 500-600 m in the middle part, and 700-900 m in the northern parts. The hydrogeological characteristics of the Quaternary reservoir and its main recharging sources were studied by Diab et al., (1981), Abdel Baki (1983); (Dahab 1994); Serage El-Din 1983, 1989; RIGW, 1988, 2001) and others.

Groundwater in the Nile Valley and the delta exists under semi confined as well as phreatic conditions. Water in the Quaternary aquifer is fresh (less than 1000 ppm) in the Nile Valley and southern and middle parts of the Nile Delta and suitable for different purposes. In northern part of the Nile delta, water is brackish to saline, where its salinity reaches more than 5000 ppm (Ebraheem et al., 1997).

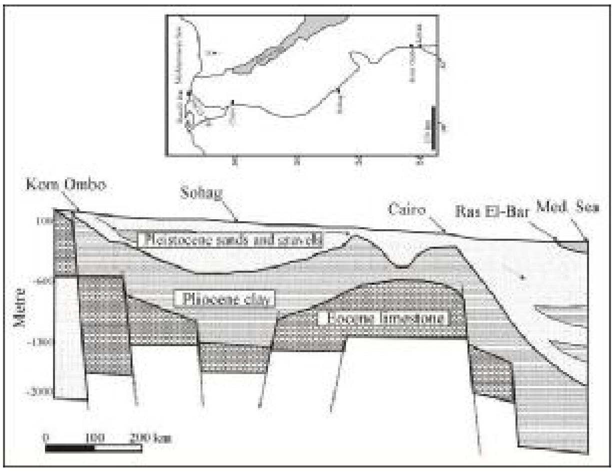

Fig. (2): Hydrogeological cross section along the Nile Valley

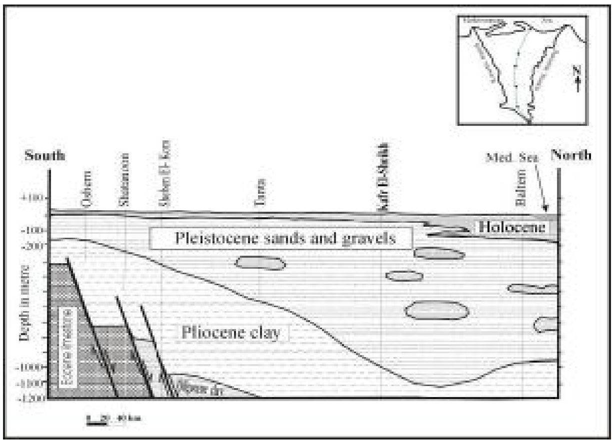

Fig. (3): Hydrogeological section along the Nile Delta

1.5.2 Miocene (Moghra) Aquifer System

Miocene hydrostratigraphic section comprises essentially the Moghra aquifer which dominating the western portion of the Nile Delta and the disconnected aquifer systems (Lower- Middle Miocene) found occasionally in the northern portion of the western desert (Fig.1), north and west Sinai, and also along the Red Sea coast.

The Middle Miocene water-bearing formations in Western Desert especially at Siwa Oasis are mainly composed of fissured and karstified limestone, which changes laterally to sandy limestone (in the eastward direction). This aquifer attains a maximum thickness of about 100 meters. This water bearing formation directly overlies the underlying Eocene water bearing formations. The recharge to the aquifer depends essentially on the upward leakage from the underlying Eocene water bearing formations and occasional local rainfall. The outcrop of the top portion of the fissured limestone (Middle Miocene) at Siwa oasis is dotted by at least 200 natural springs, having a lot flow of about 200.000 m^3/day and the salinity of the water varies from 1,500 to 7,000 ppm. (RIGW, 1988).

1.5.3 The Karstified Carbonate Aquifer System

The Karstifed carbonates aquifer is represented mainly by the Miocene and the Eocene sections. The Miocene sediments are distributed along the Red Sea Coast and represents the main aquifer in the costal area. It is differentiated into lower, middle and upper Miocene units. The Middle Miocene section represents water bearing formation at some localities such as Gabal Abu Shaar El-Qibili, 20 km north Hurghada (Fractured limestone), Wadi Essl 20 km South Quseir and Gabal El-Rusas. The Eocene section is represented by the fracture limestone that covers a large part surrounding the Nile Valley in Egypt. Water exists in the fractures and fissures supplying some fractured spinets in Egypt. The aquifer is of low potential and could not be considered as sustainable sources of water supply.

The Miocene aquifer composed of fractured limestone reaching 150 meters thick at Abu Shaar El-Qibili, (El-Sharabi, 1993) and represents groundwater reservoir with medium potentiality. The water percolates the cracks, fault zone, joints. The aquifer recharge is mainly depends on the local rainfall and occasional torrential floods. Gabal Abu Shaar El-Qibili and the adjacent basement rocks represent the main water shed areas to this aquifer. At down stream of Wadi Essel, Middle Miocene section is composed of conglomerates at the base overlain by sandstone and limestone, representing a groundwater reservoir of an average thickness of about 193 m (El-Fakarany 1989) and recharged from the catchment area of the regional hydrogeological basin of Wadi Essel (Dahab et al., 1997); (Hamdan, 2004); (Abdel Moneim et al. 2006). In the Westend Desert, the Eocene-Upper Cretaceous section is represented by the fissured limestone, sandstone and marly limestone which act as aquifer and especially recharged by the upward leakage from the underlying Nubian sandstone aquifer. The hydrogeology of the fissured limestone is better understood in Siwa Oasis (Shata. 1982), where the fissured limestone complex having a thickness of about 650 m.

1.5.4 The Nubian Aquifer System

The Nubian aquifer system in Egypt is formed by pre-tertiary sediments and is part of the Nubian aquifer system of the east Sahara, which also includes the Kufra basin in southeast Libya and northeast Chad and parts of north Sudan. The Nubian aquifer system in Egypt is bounded to the north by the saline-freshwater interface which stretches roughly along the latitude 29° N and to the east by the basement complex of the Eastern Desert (Fig.1). In the south, the aquifer is bounded by Gabal Oweinat- Aswan uplift system where sediments reach up to 700 m in thickness and ensure a hydraulic groundwater connection north Sudan. To the west, the system is not bounded, so that the Libyan border should be assumed for any calculation of the groundwater in Egypt (Thorweihe, 1990).

Compared to the other groundwater aquifers in Egypt, the Nubian sandstone aquifer is considered as the most important source of ground water in Egypt. It could be considered as the only aquifer that could contribute to the water resources in Egypt. It covered a vast area of the Western Desert of water extracted form the aquifer is the main sources of irrigation in these area. Fig. (4) shows a the thickness distribution of the Nubian aquifer in Egypt.

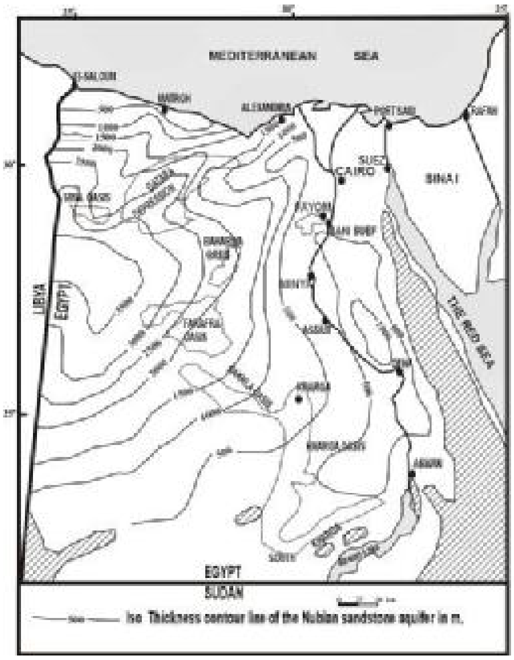

Fig. (4): Thickness of the Nubian sand stone aquifer in Egypt

1.5.5 The Fractured Basement Water Bearing Formation

The Precambrian basement rocks in Egypt include the fractured igneous and metamorphic water bearing formations occupying southern Sinai and south Eastern Desert (Fig. 1). The groundwater occurrence in these rocks is controlled with the presence of the joints, fractures, faults and dykes, where the groundwater percolates along the fractures and faults and seeps on the surface at some localities in the Eastern Desert. The presence of basic and acidic dykes forms a local groundwater reservoir in the fractured granitoid and metamorphic country rocks, where the dykes hinder the movement of groundwater in the fractured rocks, consequently the groundwater accumulates upstream of the dyke. The groundwater occurrence in the fractured Precambrian rocks was studied by many reseach groups (Shaaban 1967; Salah 1993; Abedl Mogheeth et al. 1988; El-Ghazawi et al., 1990; El-Sharabi 1993; Hamdan 2004; Abdel Moneim et al., 2006). The recharge of the fractured Precambrian water bearing formations depend mainly on the heavy rain storms and occasional torrential floods that occurred during the autumn seasons. Although, the aquifer potential of the basement rocks is very limited and could not be considered as sustainable water resources for development, it is considered as very important source (and the only sources) of water for the local communities that spreading over the desert areas especially at the Eastern Desert of Egypt.

2. Evaluation of water requirements in Egypt

2.1. The Agricultural Water Requirements

The cultivated and cropped areas are increasing over the past few years and will continue increasing due to the Government policy to add more agriculture lands. The consumption of water for agricultural sectors represents almost 80 % water consumption in Egypt (see Table 1). According to MWRI, (2002), the government objective is to enlarge the total irrigated areas (in 1997 was about 8 million fadden), by reclaiming some 3.4 million fadden (1 feddan = 1.04 acre) up to the year 2017. Thus, Egypt will face the challenge to provide water to reclaim such areas depending upon surface water or groundwater resources. In fact, at present, the groundwater is mismanaged and need sets of regulations to improve the effective utilization of such resource. Most of the wells in the Eastern Deserts (extract water from the Nubian aquifer) are overpumped as well as on the fringes of the Nile valley aquifer. The safe distances between wells are not fulfilled and left up to the farmers to locate them.

The largest consumers of irrigation water are Rice and Sugarcane because they have high water requirements in addition to occupying a considerable area. The average crop consumptive use for year 2002 was estimated to be 41.441 BCM. The total diverted water to agriculture from all sources (surface, ground water, drainage resource and sewage reuse), which includes conveyance, distribution, and application losses; 99\2000 was about 60.731 BCM (i.e. irrigation efficiency is around 68 %).

2.2 Municipal Water Requirements

Municipal water demand includes water supply for major urban and rural villages and was estimated as 4.6 BCM in 2000 (see Table 1). Part of that water comes from the Nile system and the other part comes from groundwater source. A small portion of the diverted water (about 1 BCM) is actually consumed while the reminder returns back to the system. The major factor affecting the amount of diverted water for municipal use is the efficiency of the delivery networks. The studies showed that the average efficiency is as low as 50 %, and even less in some areas. The cost of treating municipal water can be reduced significantly as the efficiency of the distribution network increases.

2.3 Industrial Water Requirements

There is no accurate estimate for the current industrial water requirement especially with the new government policy to encourage private sector participation in industrial investment. Over the last few years, there is a considerable progress in industrial development in Egypt. At least around 15 industrial areas have been established over the country. Most of these areas are located in the desert areas, thus putting more pressure on the government to provide water supply to these areas. The estimate value of the water requirement for the industrial sector during the year 2000 was 7.53 BCM. A small portion of that water is consumed through evaporation during industrial process (only 0.79 BCM) while most of the water returns back to the system in a polluted form.

3.4 Navigation Water Requirement

The river Nile main channel and part of the irrigation network are being used for navigation. Water demand specifically for navigation occurs only during the winter closure when the discharges to meet other non – agriculture demand are too low to provide the minimum draft required by ships. The water goes directly to the sea as fresh water. After changing the winter closure system by dividing the country into 5 regions instead of two, the amount of water released for navigation is considered to be significant.

However in the year 2000, an amount of 6.517 BCM of fresh water went directly to sea because of the high flood occurs this year and the past two years. Normally, the release of fresh water to sea is about 0.26 BCM/year. In general, the release water to the sea during the high flood season is presently controlled by the Nile water controlling system to minimize the flow to the sea.

3. Factors controlling the water resources development in Egypt

There is a wide range of factors that might have either a positive or a negative relationship with water resources. Some of these factors affect water supply, others affect demand while others have effects on the pattern of these resources that could be reflected in the retune of this use.

3.1 Population Growth

Where population count tripled during the last 50 years from 19 millions in 1947 to about 72 millions in 2006 and it is expected to be about 95 millions by the year 2025. Thus, the future water policy should consider this population as the targeted users of these resources. The per capital share of Nile water will drop sharply under all standards of water poverty within the next two decades unless a strong and very ambitious plan to develop Egypt‘s water resources.

3.2 The Attitude of Farmers and Other Population Sectors

The attitude of farmers and other population sectors determines the practices of their use of water. Regardless of all expenditures paid for the new irrigation systems in new lands, most farmers tend to ignore the existence of these systems to restrict themselves to provide each crop with its actual needs. Thus, all components whether knowledge, believes, or experience should be changed through an effective scientific approach that affects these practices. However, this should go hand in hand with other changes needed in water distribution system to ensure fair, timely, and efficient distribution process. Rational practices of water use and the high economic value of water were found closely related to the farmer's educational status and the type of irrigation system applied. Right knowledge is a prerequisite for positive attitude and rationale practices of water use. The awareness campaigns about the value of water should be undertaken to impose rational use of water on all users whether in the agricultural, industrial, or other sectors.

3.3 The Institutional Scheme of Water Irrigation Use

The government of Egypt has been encouraging the farmers (in the old lands) to establish their own informal social organizations to formulate their network of relationships during interaction for irrigating their lands. The main task of such organization is to avoid any sort of conflict that might occur within the distribution process of irrigation water. These organizations are powerful enough to impose themselves on all individuals through a variety of social means, social control methods, and social norms. It would be rather wiser to plan for the development of existing social organizations as subsystems related to the whole irrigation system but reconstructed on different bases. A new dynamic and handy information system for irrigation and water use should be introduced to farmers and be acceptable (MWRI, 2002). New technical agreements and technologies should be offered to these organizations in the irrigation process. The social organization of irrigation should be viewed and analyzed fully as a complete and open social system that needs urgent and rational intervention.

3.4 Employment Generation and Development Policies

Employment generation constitutes the forth determinant in the years represented about 35 % of the whole population in 2000 (EEAA 2001). This shows the potential in coming labor force within the next two decades which means there will be higher demand on employment opportunities in the next 20 years. New job opportunities should be generated depending on the use of all natural resources available including water as the scarcest resource. Agriculture is considered one of the most capital sectors to absorb the incoming labor force. However, generating new jobs in agriculture depends directly on the availability of water resources for reclamation of a new land and the establishment of new settlements.

3.5 Land Resources

Where the total area of Egypt is 1,001,450 km2, the majority of which is desert land. Most cultivated lands are located close to the Nile banks, its mean branches and canals. The per capita cultivated land declined from about 0.23 feddan in 1960 to about 0.13 feddan in 1996. The per capita crop area declined from 0.4 feddan in 1960 to about 0.2 feddan in 1996. The sharp decline of the per capita of both cultivated land and crop area resulted in the decrease of the per capita crop production. This affects directly the food security at the individual family, community and country levels. Accordingly, the government has committed itself to undertake huge projects for transferring water to potentially reclaimable lands located out of the narrow strip of the valley and delta to absorb the population increase and to offer new job opportunities.

In 1996 the Toshka project was initiated to reclaim and cultivate 0.5 million feddan on the Western Desert of Egypt using the water from Lake Nasser (Fig.5). the project involved the installation of the world's largest pumps, which will carry water into a long canal. Twenty four pumps have been installed to raise water to a canal. The canal is 50 km long and will have the capacity to provide 25 million m3 per day for irrigation areas totaling 540,000 feddan are being planned for agriculture (see Fig. 5), and establishment of integrated agricultural and industrial communities based on agricultural and agricultural –related industries.

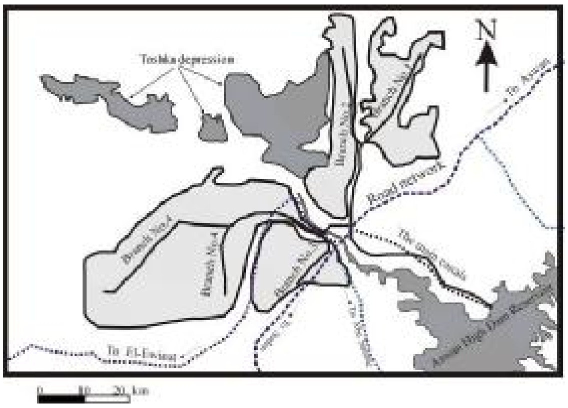

Fig. (5): The Toshka project

3.6 The Land Tenure System

The current system resulted from the limited growth rate of arable lands along with the high growth rate of population. The average holding size of lands dropped to about less than 1 feddan in 2004 with the large number of holders and the tinny farms irrigate. That resulted in:

a- Rendering part of these lands uncultivated for the purpose of digging canals, drains, roads and the border limits,
b- Losing part of the water resources during the irrigation process to reach each tinny small plot,
c- Increasing costs of operating and maintenance of irrigation canals and drainage system,
d- Suffering from the management problems and lack of coordination among the huge number of users during the operating of the water distribution system.

The Ministry of Water Resources and Irrigation has adapted the project of irrigation improvement to increase the efficiency of the irrigation and alleviate the waste of water during the operating of the irrigation system. It is quite clear that, under the trend of rapid population growth and then limited land resources along with the inheritance lows, the number of percentage of tinny and fragmented farms will gradually increase. Hence, there is a need to absorb the trends of fragmentations and amalgamation closely.

3.7 The Cropping Pattern

The cropping pattern has been freed due to the liberalization process of the agricultural sector. The cropping pattern should provide farmers with the completely free choice regarding crops they prefer to cultivate. The only limitation of this fee choice is the area to be cultivated with rice due to its high water requirements within the liberalization process. Other economic measures can be taken to encourage cultivation of alternative high cash, value added and export crops which may decrease the cultivation of water hungry crops such as rice and maize.

3.8 The Policy of the Food Security

The food gap of some main crops is expected to increase widely within the next two decades. Unless a very ambitious and serious plan to expand land resources, rationalize the use of limited water resources, and increase the efficiency of using both land and water in agricultural production to its maximum, food security in basic crops can never be achieved.

3.9 The Cost of Water and its Recovery

Recent studies showed that the cost of 1,000 m^3 of water ranged between 10 and 20 Egyptian pounds (1.8 and 3.6 US$) (MWRI 2002). The approach of water pricing is not acceptable by the majority of farmers. This means that the idea of cost recovery needs further in depth socio-economic studies to identify the approach to be used under the different conditions. In general, those who tend to accept the idea of cost recovery are more educated, large farm holders who tend to use modern irrigation methods.

3.10 Scarcity of water resources

As mentioned earlier, the Nile River provides Egypt with about 98 % of its fresh water resources. The country share of the Nile water is fixed at 55.5 BCM per year. At present, the balance between resources and requirement is achieved through water recycling and reuse. This provides a delicate situation with respect to future developments and related increased of water demand. In addition, the aviation, the availability of water of acceptable quality is limited and getting even more restricted, while at the same time the need for more water is an inevitable result due to the vast population growth, industrial development and cultivation of desert land.

The river supplies water to population of more than 65 million people, resulting in a per capita water share of less than 1000 m^3 per year, a level some suggest is an approximate minimum necessary for an adequate quality of life in a moderately developed country. Water resources management will become increasingly critical in the near future as the current water plans foresee a per capita water availability of less than 600 m^3 per year by the year 2025.

3.11 Water Pollution

Poor water quality has effects not only on aquatic eco-system but also on the suitability and the treatability of water for the different purposes. The principal causes of water pollution and quality degradation are well known, untreated domestic and industrial discharge, (improper or even proper use is a source of water contamination] use of fertilizers and pesticides, solid waste disposal, and unplanned urban and rural development. These can have potentially damaging impacts on human health, agricultural and industrial production aquaculture and ecology.

The quality of water is generally good especially in the Nile River upstream of Cairo, mainly due to the assimilative capacity of the River. Most of the industrial activities exist around the Greater Cairo area and near the City of Alexandria with almost 16 millions living there. Serious water quality problems are apparent with many pollutants in both the river water and bottom sediments. As the Delta Barrage, (north of Cairo) water quality deteriorates in a northward direction. The deterioration in the water quality is due to the decrease in the amount of flow in its branch on its way to the Mediterranean accompanied by the disposal of municipal and industrial effluent and agricultural drainage (EEAA 2001). Nevertheless, as in most developing countries, Egypt suffers from water pollution generally because of domestic, industrial, and agricultural activities. In general, water quality problems fall into two boards categories: microbiology contamination responsible for acute diseases and chemical contamination, which poses cumulative and chronic health risks to human beings and aquatic life.

3.12 Climatic Changes

Analysis of historical and recent fluctuations in water resources reflects a variety of both natural and anthropogenic causes. Natural factors include changes in precipitation, evaporation, and vegetation, while anthropogenic factors include human induced land cover and creation of artificial water bodies.

Climatic changes may also have an impact on water demands as well. It is expected that changes in temperature would result in an increase in crop water consumption. This would significantly increase the country's water demands as agriculture represents the main water user. However, no reliable climatic models are available on regional level and there is no established methodology for assessment of climatic changes on water resources. Thus impact of climatic changes on water resources in Egypt is not yet well identified.

Conclusion

The growing population of Egypt and related industrial and agricultural activities has increased the demand for water to a level that reaches the limits of the available supply. Also, water resources are of great economic significance for the population in Egypt, it is an important raw material for agriculture and industry and other sectors in the economy. Water resources also play a very role with regard to social objection. In fact water resources are of importance in increasing employment in all sectors of society and to create an acceptable distribution of the national income.

Egypt covers very arid regions situated between the Sahara and Arabian deserts. It is extremely dependant on the River Nile, being the most down stream country in the Nile basin. This makes co-operation with other Nile basin countries in dispensable. At the same time the country hardly has any other fresh water resources. Rainfall is very rare, except for a very small trip along the coast of the Mediterranean. Fossil groundwater is available in parts of the Western and Sinai. The Nile valley aquifer could not be considered as water resources as it is recharged from the access of the irrigation water.

There are many water-related challenges facing Egypt. The most important challenge is Egypt's expected population growth, the need for extending the cultivated areas to enlarge the populated area across the country, the industrial growth and to improve the quality of water resources. Such challenges could not be met without a comprehensive political and managerial plan to improve the water resources management in the near future. The success of these efforts will depend on different factors including; The excepted population growth, the attitude of farmers, the institutional set up of water irrigation use, the cultivated land resources, the land tenure system, the cropping pattern, the policy of the food security, the cost of water, and water pollution problems.

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