EGYPT

ABSTRACT

Egypt is one of the countries facing great challenges due to its limited water resources represented mainly by its fixed share of the Nile water and its aridity as a general characteristic.

Formulation of Egypt's water resources policy for the 21st century requires a major shift from the classical paradigm used in water resource planning and management to a new innovative paradigm. Dynamic interrelationships among water resource system components impose the integrated approach on policy makers.

Egypt prepared its first water policy after the construction of the Aswan High Dam in 1975. Since then, several water policies were formulated to accommodate the dynamics of the water resources and the changes in the objectives and priorities. The most recent policy was drafted in 1993. It included several strategies to ensure satisfying the demands of all water users and expanding the existing agricultural area of $7.8x10^6$ feddans (1 feddan = 1.04 acre) by an additional $1.4x10^6$ feddans. As the next century approaches, new strategies have to be adopted.

This paper provides information about Egyptian water resource development, and its determinant factors, evolution of the previous water policies, the future vision to face the enormous development challenges and the means to achieve such policies.

1. INTRODUCTION

Egypt is an arid country, which covers an area of about 1,000,000 km^2 of which only 4% is occupied by its population. According to the 1996 census, the population has reached $62x10^6$

inhabitants of whom about 99% are concentrated in the Nile Valley and Delta. One of the important issues in the future is to redistribute the population over a larger area. To reach this objective, it is essential to reclaim new lands, create new industrial regions, build new cities, hospitals, schools, etc. in order to create new jobs and provide the required food for the new communities. The agricultu
exceeding 80% of the total demand for water. In view of the expected increase in water demand from other sectors, such as municipal and industrial water supply, the development of Egypt's economy strongly depends on its ability to conserve and manage its water resources.

Two main land reclamation projects have been launched to form the base for population redistribution and further economic development. The first is the El-Salam canal west of the Suez Canal and El-Sheikh Jaber east of the Suez Canal to reclaim about 620,000 feddans (1 feddan = 1.04 acre). The second project is the El-Sheikh Zaied Canal, which will reclaim some 500,000 feddans in the south of the New Valley. These two projects require huge investments but they do have major social, economic and institutional benefits. The main constraint to implement these projects is the amount of water available. It is well known that the water resources in Egypt are limited to the 55.5 BCM ($x10^9$ m^3) share of Egypt in the flow of the river Nile (55.5 BCM), the deep groundwater in the deserts (mostly non-renewable), and a small amount of rainfall in the northern coastal area and Sinai. Meanwhile, water demand is continually increasing due to population growth, industrial development, and the increase of living standards. Because of population growth, the per capita share of water has dropped dramatically to less than1000 m^3/capita, which, by international standards, is considered the "Water poverty limit". The value may even decrease to 500 m^3/capita in the year 2025.

The Ministry of Public Works and Water Resources (MPWWR) is formulating the national water policy for the 21st century to face the challenges of water scarcity. The policy's overall objective is to utilize the available conventional and non-conventional water resources to meet the socio-economic and environmental needs of the country. The formulated policy focuses on the following :

- Shift the management from the supply-oriented approach to the integrated approach that considers both supply and demand sides of the equation.
- Demand management that requires improving water use efficiencies.
- Developing new water resources through increasing Egypt's share in the Nile water through water conservation projects in the Upper Nile, harvesting rainfall, and desalinating brackish groundwater of 3000-12000ppm salinity.
- Environmental protection of water resources.

2. POPULATION GROWTH

The first determinant for water resources development is the population growth where the population has tripled during the last 50 years from $19x10^6$ in 1947 to about $62x10^6$ in 1996 and it is expected to be about $95x10^6$ by the year 2025.

3. LAND RESOURCES

The total area of Egypt is 1,001,450 km^2 the majority of which is desert lands. Most cultivated lands are located close to the Nile banks, its main branches and canals. Currently, the inhabited area is about $12.5x10^6$ feddans and the cultivated agricultural land is about $7.85x10^6$ feddans.

The per capita cultivated land declined from about 0.23 feddans in 1960 to about 0.13 feddans in 1996. The per capita crop area declined from 0.4 feddans in 1960 to about 0.2 feddans 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.

3.1 Land Tenure System

The current system of land tenure 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 1.5 feddans in 1995 with a large number of holders and tiny farms to irrigate.

The Ministry of Public Works and Water Resources has adapted the project of irrigation improvement to increase the efficiency of irrigation and alleviate the waste of water during the operation of irrigation systems. It is quite clear that, under the trend of rapid population growth and the limited land resources along with the inheritance laws, the number and percentage of tinny and fragmented farms will gradually increase. Hence, there is a need to closely observe the trends of fragmentation and amalgamation.
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4. STATUS OF WATER RESOURCES

4.1 Status of Water Supply

Water resources in Egypt are limited to the following resources:

- Nile River,
- Rainfall and flash floods,
- Groundwater in the deserts and Sinai and
- Possible desalination of sea water.

Each resource has its limitation on use, whether these limitations are related to quantity, quality, space, time, or use cost. The following is a description of each of these resources.

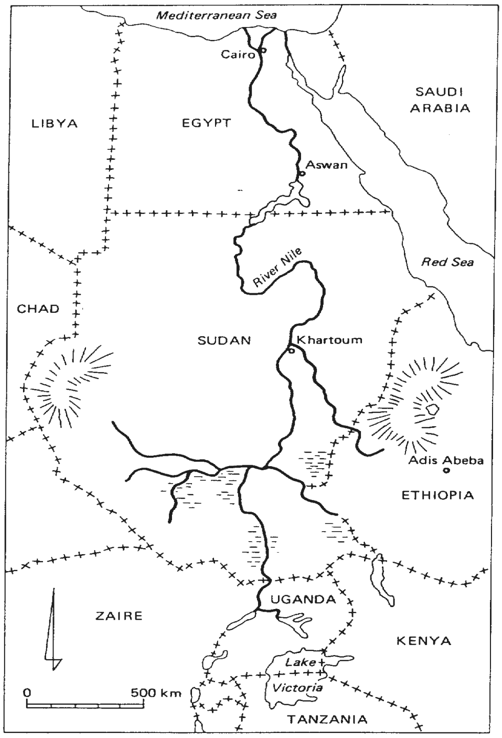
Nile River Water

Egypt's main and almost exclusive resource of fresh water is the Nile River. The Nile River inside Egypt is completely controlled by the dams at Aswan in addition to a series of seven barrages between Aswan and the Mediterranean Sea. Egypt relies on the available water storage of Lake Nasser to sustain its annual share of water that is fixed at 55.5 BCM annually by agreement with Sudan in 1959. The agreement allocated 18.5 BCM to Sudan annually assuming 10 BCM as evaporation losses from Lake Nasser each year based on an average annual inflow of 84 BCM/year. This average was estimated as the annual average river inflow during the period 1900 till 1959.

Rainfall and Flash Floods

- Rainfall

Rainfall on the Mediterranean coastal strip decreases eastward from 200 mm/year at Alexandria to 75 mm/year at Port Said. It also declines inland to about 25 mm/year near Cairo. Rainfall occurs only in the winter season in the form of scattered showers. Therefore, it can not be considered a dependable source of water.



Map of the Nile Basin

- Flash Floods

Flash floods due to short-period heavy storms are considered a source of environmental damage especially in the Red Sea area and southern Sinai. Many studies have been made to determine possible measures to avoid hazards caused by flash floods. Mechanisms have also been developed to harvest flash floods water. 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.

Groundwater in the Western Desert and Sinai

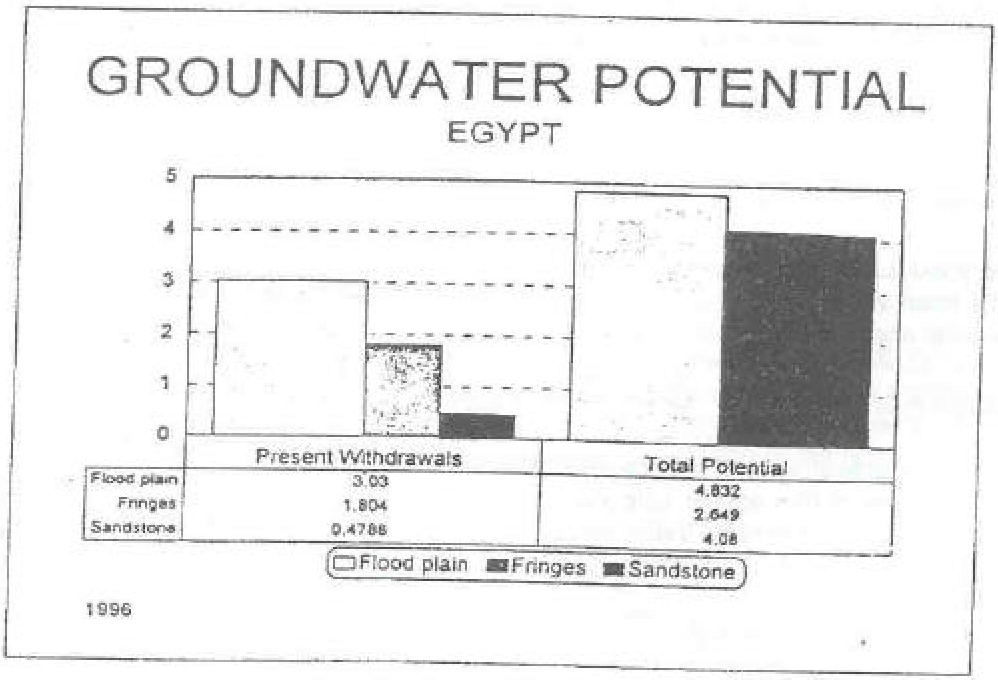
- Groundwater occurs in the western desert in the Nubian sandstone aquifer that extends below the vast area of the New Valley governorate and the region east of Owaynat. It has been estimated that about 200,000 BCM of fresh water are stored in this aquifer. However, groundwater occurs at great depths and the aquifer is generally non-renewable. Therefore, the
- utilization of such water depends on pumping costs and its depletion rate versus the potential economic return on the long run.

- Groundwater in Sinai is mainly encountered in three different water-bearing formations; the shallow aquifers in northern Sinai, the valley aquifers; and the deep aquifers. The shallow aquifers in the northern part of Sinai are composed of sand dunes that hold the seasonal rainfall, which helps to fix these dunes. The aquifers in the coastal area are subject to salt-water intrusion. The total dissolved solids in this water range from 2,000 to 9,000 ppm which can be treated to reach a suitable salinity level for use to irrigate certain crops.

- The groundwater aquifers in the valleys of Sinai are recharged from rainfall and especially from heavy storms. The annual rainfall on Sinai varies from 40 mm to 200 mm/year. Most of the rainfall water recharges the shallow groundwater aquifers in northern Sinai such as the delta of Wadi El-Arish and El-Beqaa flood-plain, while such aquifers are absent in southern Sinai. Although most of the shallow aquifers are renewable, only 10 to 20% of the deep aquifers are renewable by rainfall and flash floods.

- The total groundwater abstraction in the western desert in 1995/96 was estimated to be about 0.48 BCM while it is only 0.09 BCM/year in Sinai.

Groundwater Potential : Ground water development has started in the early sixties and is continuing. Figure below illustrates the present ground water use (1996) and future potential in the major ground water systems of the country. From this it is observed that the present use is concentrated in the Nile aquifer system, followed by the desert fringes and the Nubian sandstone. Other aquifer systems are still underdeveloped. Moreover, within the developed systems, only part of the potential is utilized mainly where ground water is fresh.



Groundwater Use and Potential in Egypt (1996)

Desalination of Sea Water

- Desalination of seawater in Egypt has been given low priority as a source of water. That is because the cost of treating seawater is high compared with other sources, even the unconventional sources such as drainage reuse. The average cost of desalination of one cubic metre of seawater ranges between 3 to 7 L.E (Egyptian pound). In spite of this, sometimes it is feasible to use this method to provide domestic water especially in remote areas where the cost of constructing pipelines to transfer Nile water is relatively high.

- Egypt has about 2,400 km of shorelines on both the Red Sea and the Mediterranean Sea. Therefore, desalination can be used as a sustainable water resource for domestic use in many locations. This is actually practised in the Red Sea coastal area to supply tourism villages and resorts with adequate domestic water where the economic value of a unit of water is high enough to cover the costs of desalination.

- The future use of such resource for other purposes (agriculture and industry) will largely depend on the rate of improvement in the technologies used for desalination and the cost of needed power. If solar and wind energy can be utilized as the source of power, desalination can become economic for other uses. 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. Nevertheless, brackish groundwater having a salinity of about 10,000 ppm can be desalinated at a reasonable cost providing a possible potential for desalinated water in agriculture.

- The amount of desalinated water in Egypt now is in the order of 0.03 BCM/year.

4.2 Non-conventional Water Resources

There exist other sources of water that can be used to meet part of the water requirements. These sources are called non-conventional sources, which include :

- The renewable groundwater aquifer in the Nile basin and Delta
- The reuse of agricultural drainage water
- The reuse of treated sewage water

These recycled water sources cannot be considered independent resources and cannot be added to Egypt's fresh water resources. They sources need to be managed with care and their environmental impacts evaluated to avoid any deterioration in either water or soil quality.

- The renewable Groundwater Aquifer in the Nile Valley and Delta

The total available storage of the Nile aquifer was estimated at about 500 BCM but the maximum renewable amount (the aquifer safe yield) was estimated to be only 7.5 BCM. The existing rate of groundwater abstraction in the Valley and Delta regions is about 4.5 BCM/year, which is still below the potential safe yield of the aquifer.

- Reuse of Agricultural Drainage

The amount of water that returns to drains from irrigated lands is relatively high (about 25 to 30%). This drainage flow comes from three sources; tail end and seepage losses from canals; surface runoff from irrigated fields; and deep percolation from irrigated fields (partially required for leaching salt). None of these sources is independent of the Nile River. The first two sources of drainage water are considered to be fresh water with relatively good quality.

The agricultural drainage of the southern part of Egypt returns directly to the Nile Rive where it is mixed automatically with Nile fresh water which can be used for different purpose downstream. The total amount of such direct reuse is estimated to be about 4.07 BCM/year in 1995/96. In addition, it is estimated that 0.65 BCM/year of drainage water is pumped to the El-Ibrahimia and Bahr Youssef canals for further reuse. Another 0.235 BCM/year of drainage water is reused in Fayoum while about 0.65 BCM/year of Fayoum is drained to Lake Qarun. Moreover, drainage pumping stations lift about 0.60 BCM/year of Giza drainage from drains to the Rossita Branch just downstream of the delta barrages for further downstream reuse.

Drainage water in the Delta region is then emptied to the sea and the northern lakes via drainage pump stations. The amount of drainage water pumped to the sea was estimated to be 12.41 BCM in 1995/96. This decreased and will continue to decrease in the future according to the development of the reuse of agricultural drainage water.

Reuse of Treated Waste Water

One way of augmenting the irrigation water resources is to reuse treated domestic wastewater for irrigation with or without blending with fresh water. The increasing demands for domestic water due to population growth, improvement in living standards and the growing use of water in the industrial sector due to the future expansion of industry will increase the total amount of wastewater available for reuse.

Wastewater treatment could become an important source of water and should be considered in any new water resource development policy. However proper attention must be paid to the associated issues with such reuse. The major issues include public health and environmental hazards as well as technical, institutional, socio-cultural and sustainability aspects.

4.3 STATUS OF WATER DEMANDS

Demands for water can be categorized in four main classes.

a. Crop Consumptive Use

The average annual consumptive use for 1995/96 was estimated to be 40.82 BCM. In that year about $7.8x10^6$ feddans were irrigated with an average water consumptive use per feddan of about 5100 m^3/year. This amount represents only the crop evapotranspiration and does not include conveyance losses in the irrigation network or seepage and deep percolation loses at the farm level.

b. Municipal Water Requirements

The total municipal water use was estimated to be 4.54 BCM in 1995/96. A portion of that water is actually consumed and the rest returns to the system, either through the sewage collection system or by seepage to the groundwater. There are regions like Alexandria, the Suez Canal, and desert areas where the discharge cannot be recovered.

c. Industrial Water Requirements

The estimated water requirement for the industrial sector during the year of 1995/96 was in the order of 7.5 BCM/year. A small portion of the diverted water for industrial requirement is consumed through evaporation during industrial processes while most of the water returns to the system.

d. Navigational Requirements

The river Nile main stream and part of the irrigation network are used for navigation. Water demand specifically for navigation occurs only during the winter closure period (about 3 weeks in January and February), when discharges to meet agriculture demands are too low to provide the minimum draft required by ships.

4.4 Summary of Water Resources Balance

In summary the actual resources currently available for use are 55.5 BCM/year, whereas water demands for all the sectors are in the order of 65 BCM/year. Recycling and better management nearly overcomes this gap between water needs and demands. Currently groundwater abstraction is about 4.8 BCM/year. An amount of 4.3 BCM/year of drainage water is now re-used. Another 0.4 BCM/year of treated wastewater is re-used for irrigation at present which still leaves a small deficit of demand over supply.

4.5 Water Quality Status

In general, the water quality of Lake Nasser is considered good. However, some threats can be identified if the settlements around the lake and in the upstream catchment area increase without taking the proper provisions to abate water pollution.

The quality of water released from Lake Nasser affects the quality of the Nile River downstream of the High Aswan Dam. The change in water quality of the river along its way own to the Delta is illustrated by the longitudinal profiles. Comparing the profile for 1976-1978 and 1991, it can be concluded that no significant changes have occurred so far on salt content or dissolved oxygen (DO), but a broader view of quality parameters shows some deterioration in the quality.

On the contrary, drainage canals, which are basically designed to collect the drainage of agricultural areas, receive increasing quantities of untreated or partially treated industrial wastewater, sludge and even solid wastes.

5. FUTURE POLICIES FOR THE DEVELOPMENT OF WATER RESOURCES

The main elements of future policy are:

5.1 Optimal Use of Available Resources

The optimum use of all available water resources can be achieved through an integrated plan at both national and local levels translating the overall policy targets into long term programs after reviewing and examining their impact on socio-economic development.

The following is a set of proposed strategies to achieve optimum use of all the available water resources.

Minimize Water Losses by:

a. using pipelines to transfer water in the new lands especially where there are highly permeable soils;

b. gradual expansion of groundwater wells for use as a secondary source of water at the farm level to decrease conveyance losses in third order canals;

c. replacement of level-based water distribution systems to flow-based water distribution systems through calibration of control;

d. introduce new technologies for canal maintenance and weed control; and

e. improve the Nile River navigation channel and facilities to reduce, or eliminate, the amount of water released for that purpose during the winter period.

Irrigation Improvement Projects include:

a. rehabilitating and renewing water structures,
b. using pipeline and raised mesqas,
c. the use of one-point collective pumping from branch canals into mesqas, and

d. land leveling using modem techniques.

The improvement projects also include the redesign of field irrigation systems and, most importantly, the formulation of water user associations that express the new vision for the water distribution management process.

Cost Recovery

Setting up a cost recovery system in which water users pay for the services of water distribution and network maintenance.

This program will initiate public awareness on cost allocation and cost recovery programs It will inform the media of the importance of water and encourage the implementation of water user's association groups. These groups will be supervised by water association supervisors who will facilitate and coordinate between farmers to ensure that they work as one team towards achieving the MPWWR strategies. It will also be a good way to transfer and exchange knowledge between different users and promote transparency and accountability. It should secure public support and commitment to water policies and programs.

Shifts in Cropping Patterns

Encouraging policies to reduce the consumption of agriculture water by:

- Gradually replacing sugarcane with sugar beets especially in Upper Egypt taking into account the lifetime of current sugar factories, which were designed to process sugarcane.
- Reducing the cultivated rice area to about $9x10^5$ or $1x10^6$ feddans which will be sufficient to satisfy national demand, provide some potential for export, and prevent soil salinization and seawater intrusion.
- Replacing currently used varieties of rice with the new shorter-life rice varieties which have a higher productivity and lower water requirement due to their shorter lifetime.
- Using genetic engineering develop new crop varieties that have higher productivity and consume less water.
- Narrow the gap between net revenues of similar seasonal crops to enable the MPWWR to encourage lower water consumptive crops.
- Design an indicative cropping pattern for each region based on climatological conditions, soil characteristics and available water resource in terms of quantity and quality. Farmers should be advised to follow the indicative cropping pattern or pay for excess water if they deviate.

5.2 Develop Groundwater Strategies

The future strategy for groundwater development would aim to encourage agricultural development of desert areas. These areas would involve initiating new communities that can absorb part of the highly concentrated population in the Nile valley and Delta. Such approach will increase the future demands for groundwater, which consequently will need continuous monitoring and evaluation of the groundwater aquifers to avoid any possible deterioration in these aquifers due to misuse.

The Renewable Aquifer Underlying the Nile Valley and Delta

The strategy for groundwater envisages the conjunctive use of Nile surface and groundwater through:

- Using the aquifer as a storage reservoir to supplement surface water supply during peak periods and recharging during the minimum demand periods.
- Use of modern irrigation methods (sprinkler or trickle) in the new lands that uses groundwater as the source of water to prevent water logging and keep the groundwater table far from the root zone.
- Use a vertical well drainage system in Upper Egypt to prevent the groundwater table from reaching the root zone thus avoiding water logging and increasing productivity.
- Groundwater could be used as a source of water for artificial fish ponds as it has a consistent and steady temperature and good quality.
- Augment the canal water supply by pumping groundwater from low capacity private wells at tail ends of long mesgas where water shortage is experienced.

Groundwater Aquifers in the Western Desert and Sinai

Groundwater occurs at great depths and needs a large investment to be profitable. Therefore future strategies to use groundwater in the Western desert and Sinai include:

- the use of the modern technologies to determine the main characteristics of each aquifer, its maximum capacity and safe yield. These data should be the basic criteria for selecting the most suitable projects that can use such aquifers as a sustainable source of water.
- New small communities ($2x10^3$ to $5x10^3$ feddans) in the desert areas designed to use all available natural resources through integrated planning.
- Use non-conventional sources of energy such as solar and wind to minimize the costs of pumping.
- Use the new technologies for farm irrigation in desert areas to minimize field losses especially deep percolation due to the high porosity of such soils.

5.3 Reuse of Agricultural Drainage Water

The strategies for drainage water reuse include the following measures:

- Increasing the reuse of drainage water from about 4.5 BCW/year to 7.0 BCM/year by year 2000 and to 9.0 BCW/year by year 2017 with average salinity of 1170 ppm. This could be achieved through implementing several projects to expand the reuse capacity at different areas. Main future projects include the El-Salam canal project, the El-Omoom and El-Batts drainage project;.
- Improving the quality of drainage water especially in the main drains;
- Separating sewage and industrial wastewater collection systems from the drainage system;
- Draining 50% of the total generated drainage water in the delta into the sea to prevent seawater intrusion, and to maintain the salt balance of the system;
- Implement an integrated information system for water quality monitoring in drains using the existing data collection network after updating and upgrading; and
- Continuous monitoring and evaluation of the environmental impacts due to the implementation of a drainage water reuse policy especially on soil characteristics, cultivated crops, and health conditions.
- Reuse of Sewage Water
- The future policy for using sewage water can be summarized as follows:
- Increase the amount of secondarily treated wastewater use from 0.26 BCM/year to 2.8 BCM/year by 2001 and to 4.5 BCM/year by 2017;
- Limit the use of treated wastewater to cultivated non-food crops such as cotton, flax, and trees;
- Separate industrial wastewater from domestic sewage, so that it would be easier to treat domestic sewage with minor costs and avoid the intensive chemical treatment needed for industrial wastewater.

5.5 Development of Surface Water Resources

In addition to achieving better utilization of the available water resources, the future policy also aims at investigating the possibilities of developing new water resources or increasing the availability of existing resources in order to meet future increasing demands. In that regard, the future water policy for Egypt includes the following strategies.

(i) Increasing Egypt's Share of the Nile Water through Cooperation with the Nile Basin Countries

85% of the Nile water originates from the Ethiopian highlands through the Sobat River, the Blue Nile River, and the Attbara River. Egypt's share of the Nile's water was fixed at 55.5 BCM/year by the Nile water treaty. Studies show that a large portion of the Nile water is lost before it reaches Aswan, therefore, there is a modest potential to decrease these losses through implementing joint projects with other countries in the Nile basin.

(ii) Desalination of Brackish Water

The Government is examining the possibility of using the low salinity brackish groundwater to irrigate certain seasonal crops. This water is available at shallow depths in the Western and Eastern Deserts and at the borders of the Nile valley. The average salinity of such water varies from 3000 to12000 ppm.

Non-conventional sources of energy, e.g. solar and wind energies, would be used in the treatment process to minimize the cost and increase its economic value.

This source will supplement rainfall to Increase land productivity by cultivating two crops per year instead of one.

(iii) Harvesting Rainfall and Flash Flood Water

The future strategies for flash flood risk assessment and utilization involves the use of:

a. Modern technologies such as remote sensing and GIS to study the basic characteristics of stream networks that contribute to flash floods,
b. adjusting daily releases from the High Aswan Dam to their occurrence, and
c. avoiding hazards from flash floods by implementing risk zone maps for major bottlenecks on the basin streamlines and identifying areas that lie in risk zones to take proper precautions to avoid any possible hazards.

5.6 Water Quality Management

One of the major issues facing Egypt is the accelerated decline of water quality. Water quality has a direct effect on the quantity available for a specific use. As the quality of water degenerates the areas of use narrows, thereby, reducing supplies and intensifying shortages.

Future policy aims to implement a long-term strategy to prevent the different sources of pollutants from discharging to the Nile River and other water bodies.

6. MEANS FOR POLICY ACHIEVEMENT AND SUCCESS

6.1 Public Awareness

The Govt. has launched a public awareness program aiming at :

- Informing the public, through media, the major achievements in water management.

- Explaining the significance of water saving in irrigation and domestic uses by demonstrating water saving consequences to people.
- Demonstrating, through the media and in the parliament, a simplified version of the water resources policies and its associated strategies and future plans to execute these policies.
- Achieving public participation and commitment to water policies and programs.
- Increasing the knowledge of people about new technologies in farm irrigation, and domestic uses to conserve water for future development.
- Increasing the awareness of the environmental issues related to water resources utilization.

6.2 Continuos Monitoring and Evaluation

Policy making is a dynamic and continuous process in which the formulated policy should be checked and updated according to changes in the social or the economical conditions. The policy should be monitored through a set of well-defined criteria measuring the overall performance of the policy and the results of the implementation of the selected strategies. The evaluation process should be done on a regular basis to enable strategic adjustments needed to correct deviations from the original objectives.

Realizing the need for intensive monitoring to collect the required data about water resources (quantity, quality, and level of use) and an integrated information system to store, and analyze these data to help in the decision making process of adjusting the existing water policies, the Government. has launched several monitoring programs such as the Water Quality Monitoring Program, the Drainage Water Quality Monitoring Program, and the Groundwater Quality Monitoring Program.

6.3 Improvement of Water Resources Management Systems

Integrated Water Resources Management

Water resources management is a complex process that requires a multi-disciplinary team in order to take all its facets into consideration.

The integrated water resources management approach combines these different aspects under one system that manages demand and quality of water resources as it manages supply. The Government has taken several initiatives towards applying this approach and all its principles such as user involvement and participation, organizational restructure, etc. as given below.

Users Participation in Water Management

The MPWWR bears the responsibility of coordination between the different parties and the promotion of their participation in the decision making process through establishing joint committees representing the different water users by hosting seminars and workshops to demonstrate and propagate water policies and its associated strategies.

The Irrigation Improvement Project is currently establishing Water Users Associations (WUA) that promotes farmers' involvement and participation in water management at the Mesqa level. The role of these associations will be extended to manage secondary canals by forming high level associations. This effort is one step on a long way to change from central management of water resources to participatory management of water resources. This will need the government to study privatization of some water resource activities in order to strengthen the capacity of the important water sector and to improve private sector participation it water resource management.

Institutional Strengthening

It is planned to review and update all the institutional and administrative procedures needed to enhance water resources management to reflect the integrated approach of water management and the new trends of privatization where part of the activities may be transferred to the private sector such as operation and maintenance of some parts of the network.

Human resources development would be a major aspect of institutional strengthening.

The future policy will include an intensive training program to improve the technical and management skills of the staff and to ensure the preparation of new generations that can carry the responsibility in the future. This effort will be continuous, in a flexible way that reflects modern and state-of-the-art technologies in all the ministry's activities.

Coordination between Ministries

This coordination framework is sought to strengthened through the following measures:

- Clear definition of the responsibilities of each party in the water resources management process avoiding redundancy or overlap in responsibilities.
- Clear definition of the responsibilities of joint committees making sure that committees do not replicate what other committees or authorities are presumed to do.
- Enhance the data exchange process between different authorities.
- Exchange knowledge, experiences, and technical expertise in the different fields of water resources between different authorities.

6.4 Laws and Decrees

A detailed review for all existing water resources laws and decrees should be done classifying these laws and decrees into categories according to their relation to water management aspects to ensure that the most recent version of these laws reflect the long-term objectives and the government's overall policy.

6.5 INTERNATIONAL COOPERATION

The Nile River is an international River as its water runs though ten different African countries. These countries have established good coordination links amongst them selves and issued some agreements between different parties to ensure the proper utilization of this shared resource for the benefit of all countries. This coordination must be continued and future discussions should be concentrated on the sustainable development of the water resources in the ckountries of the Nile River basin.

6.6 Use of Modern Technologies in Water Resource Management

- Future policy considers the utilization of new technologies in water resource management especially in the following areas:
- The use of satellite images and remote sensing techniques to build a geographic information system for the Upper Nile basin comprising hydro-meteorological data.
- The use of mathematical models to simulate the hydrological cycle over the whole Nile River basin to follow water movement from its sources till it reaches the High Aswan Dam.
- The use of Information Systems and Decision Support Systems in an integrated way to satisfy all the ministry's needs for information and indicators related to water resource management.

6.7 Research and Development

The policy formulation process is based on a soil foundation of applied research findings and comprehensive planning studies. Research as a dynamic process is considered the key action of the policies success. The National Water Research Center with its twelve institutes is the responsible Agency for doing research.

State of the art technology, in various aspects of water resource planning and management, adopted and utilized for the planning and formulation of Egypt's water resources policies for the 21st Century.

7. SUMMARY AND CONCLUSION

Water scarcity is a growing global problem challenging sustainable development and expansion of cultivated areas to meet increasing food requirements. Egypt is one of the countries facing great challenges, due to its limited water resources represented mainly by its fixed share of the Nile water, and its aridity is the general characteristics of the country.

The agriculture sector is the largest user of water in Egypt with its share exceeding 80% of the total demand for water. In view of the expected increase in water demand from other sectors, such as municipal and industrial water supply, the development of Egypt's economy strongly depends on its ability to conserve and manage its water resources.

Efficient and effective use of all water resources in Egypt requires the formulation and implementation of an appropriate water sector policy. The Ministry of Public Works and Water Resources (MPWWR) is formulating a national water policy for the 21st Century to face the challenges of water scarcity. The policy's overall objective is to utilize the available conventional and non-conventional water resources to meet the socio-economic and environmental needs of the country.

An assessment of water resources has been made. As a result of this analysis, a preliminary setting for various policies has been determined. The formulated policy focuses on three major aspects: demand management, resources development, and environmental protections Strategy options to be considered are :

- Conservation projects in the upper waters of the Nile Basin
- Recycling Nile aquifer water
- Recycling drainage water
- Recycling wastewater after treatment
- Utilization of desert groundwater
- Cost recovery based on cultivated area and type of crop
- Harvesting of rainfall
- Improvement of water quality
- Limitation of the rate of land reclamation
- Raising public awareness of the water problem.

These options should be integrated into the generally accepted National Water Policy for Egypt. The means that such policy achievements and successes must be presented through the following programs:

- Public awareness,
- Continuous monitoring and evaluation,
- Improvement of water resource management,
- Enforcement of laws and decrees,
- International cooperation and

- Use of modern technologies in water resource management research and development.