

# Water Resources Management: Alarming Crisis for Egypt

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Received: July 15, 2014 Accepted: August 3, 2014 Online Published: August 29, 2014

doi:10.5539/jms.v4n3p108 URL: <http://dx.doi.org/10.5539/jms.v4n3p108>

## Abstract

Water is one of the most important inputs for economic development and sustainable development; as the demand increases, so too does the importance of water. The future looks miserable if Egypt does not succeed in formulating and implementing water resources management approach which can match the limited freshwater supply with the increasing demand. This study intended to shed the light on the future water status in Egypt based on the current status of the available water resources, the water demand, the institutional and legislative frameworks of water management, adding to shed the light on the strategies and policies to rationalize water use and to augment water supply. This study intended to explore how Egypt will safeguard its water resources in the future, both with respect to quantity and quality and how it will use these resources in the best way. Recommendations to help overcome anticipated water challenges and to optimize the available opportunities were provided in this worthwhile study as knowledge of Egyptian water resource planning is presently very limited and largely undocumented. Hence, the challenges and opportunities were discussed in order to support the decision-making process concerned with water resources management as an essential prerequisite for Egypt sustainable development. The future scenarios that introduce the future challenges, using the available opportunities, were investigated and recommendations to help overcome the future challenges were presented.

**Keywords:** water quality, water policy making, water governance, sustainable development, water resource planning

## 1. Introduction

Water resources management, water quality management and environmental protection are the main concerns for sustainable development. As Andelman (2010) noted "Water is mankind's most valuable resource". Water is the one essential requirement of all forms of food production, "No Water, No Food". At the end of 1984, 21 African countries were suffering from what the UN calls "Abnormal food shortages", as 40% of Africa's total population didn't know where their next meal was coming from. World recession, civil and military conflicts all played their part but the real truth was that Africa was short not so much of food as of water. According to the UN report 1997, more than 80 countries composing 40% of the world's population were already suffering from serious water shortages and a rapid deterioration of water quality, affecting these countries' economics and social development as well as human health (Clarke, 1993; Andelman, 2010). Although water shortage is also a potential problem in developed countries and industrial nations, the rich countries can usually resort to buying their way out through the use of expensive energy, technology, and investments to recycle their water or to desalinate seawater. On the other hand, developing countries that are trapped in poverty and debt have no such option. As a result, they must either limit their use of water that has not previously been used or they must make do with used but untreated water. Unfortunately, most of developing countries that are short of water rely on inadequate solutions as the use of dirty water and most sewage is left untreated (Falkenmark, 1976).

Water remains vital to the growth and welfare of the entire Middle Eastern region. In fact, many scientists and politicians have stated that water and the control of water are key factors in the overall stability of the region (Cerveny, 2006). Some 270 basins are shared between two or more countries and as demand for water becomes more severe, better management of these shared rivers will be required to prevent sparks from occurring (Andelman, 2010).

Egypt as a poor developing country, only 4 % of its land arable, its water supplies is uncertain and its known oil reserve could be exhausted in 15 years, but rich in human resources. The concentration of the total density of the

Egyptian population is mainly located in the narrow Valley of the Nile. This high concentration accompanied with a continuous growing size of population, domestic wastewater, a growth of industrialization, as well as the consequences of a higher standard of living, the increased use of chemicals in agriculture, the absence of actual control on the disposal of hazardous waste materials development as well as the lack of environmental public awareness, all of which are considered the factors leading to a real burden on the Egyptian natural water resources. Accordingly, for Egypt, water resources management is considered an absolutely strategic priority (Allam, 2007). As the per capita size of irrigated land is shrinking and unemployment is high, national and local water management\_institutions are increasingly challenged to provide answers to the water crisis. Water resources in Egypt are confined to the withdrawal quota from the Nile water; the limited amount of rainfall; and the shallow groundwater reservoirs. Agriculture in Egypt, as in most developing countries, represents the main usage of water, followed by the residential and industrial uses. However, most data available on water uses in Egypt are approximate and are not based on field measurement because of the lack of measuring devices with accepted accuracy for the water uses for either irrigation or the municipal and industrial sectors (Allam, 2007).

From the analysis of water resource planning in Egypt, the planning emphasis can be characterized by a shift from water abundance to water deficit; the importance of international co-operation; supply bias; environmental concern; lack of data and public awareness; established priority to non-agricultural uses of water; delayed implementation; and the urgency for an establishment of an administrative framework for water resource planning. Egypt water resource planning is actually facing a number of problems mainly resulting from a lack of funds and a weak administration. However, establishing a planning system is expensive and it is therefore undertaken only if necessary. Yet, 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. As the emphasis on water resource planning depends on the scarcity of the resource. Then the greater the scarcity, the more planning is needed to counteract it. Accordingly, following a greater scarcity of its water supply, it is expected that Egypt will strengthen its water resource planning and management in the near future (Hvidt, 2000).

This qualitative exploratory study intended to provide a review of controlling factors and water resources management drivers in Egypt, introducing a vision for institutional reform to provide the proper enabling environment for an effective resources management.

A diagnosis of the Egyptian water system, policies, issues and considerations is reviewed and analyzed. Future scenarios that introduce the challenges, using the available opportunities, are discussed and investigated. This study aimed to shed the light on the future water status in Egypt based on the current status of water resources management in terms of challenges and opportunities, adding to highlight the urgent need for strategies and policies to rationalize water use and to augment water supply.

In this context, the following research questions should be explored:

- What are the drivers and the controlling factors of water resources management in Egypt in terms of the institutional and legislative frameworks of water management, as well as the strategies and policies to rationalize water use and to augment water supply?
- What are the challenges and the opportunities of water resources management in Egypt based on the current status of water resources management?
- What are the recommendations to help overcome anticipated water challenges and to optimize the available opportunities for water resources management in Egypt?

## 2. Literature Review

The international community has affirmed the human right to water in a number of international treaties, and declarations. Most notably, the United Nations (UN) Committee on Economic, Social and Cultural Rights adopted in November 2002 a general comment on the right to water setting out international standards and obligations relating to the right to water (Klawitter, 2005). Water shortage can be resulted generally from 'Aridity', a permanent shortage of water caused by a dry climate or from 'Drought', which is an irregular phenomenon occurring in exceptionally dry years, or because of the 'Desiccation', a drying up of the landscape, particularly the soil, resulting from activities such as deforestation and over-grazing. Moreover, water stress can be due to increasing numbers of people relying on fixed levels of run-off. The first two reasons are related to the climate while the second two are the result of human activities (Clarke, 1993). From sociological perspective, the importance of water resources management is related to 'Sustainability, the Rights and Beauty of the Nature and Environmental Justice' which concerns not only the rights of humans but also the rights of non-humans of animals, plants and even the land and rivers. Bell (1998) argued that any environmental impact depends on what is being

consumed, what is being produced by those increased numbers of people and on how they go about their consuming and producing. There is an indisputable association between high levels of population growth, poverty and a wide range of environmental problems. Accordingly, the threat to water is one of the serious environmental problems that need special attention (Bell, 1998). From another perspective, Hardin (1968) pointed out that the rational man finds that his share of the cost of the wastes he discharges less than the cost of purifying his wastes before releasing them. In Egypt, for example, poor people may decide to throw their garbage in the Nile or Canals because the cost for them is zero and moreover there are no alternatives for them (Hardin, 1968).

Herodotus said a long time ago that Egypt is a “Gift of the Nile”, as almost 97 percent of all the water drawn in Egypt whether for agriculture or municipal and domestic consumption is from the Nile (Andelman, 2010). Egypt is unique among the nations of the world due to its extraordinary dependence upon a single water source, the River Nile, which is the longest river in the world. For more than 5000 years, Egyptians have been managing Nile water for irrigation through a series of hydraulic structures “Dams and Barrages”. At present, Egypt is almost completely dependent on the waters of the Nile and Egypt supplements its supply with small amounts of rainfall, floodwater, groundwater, agricultural drainage water and treated municipal water. Despite access to these water sources, many researchers and observers regularly predict intense water scarcity in Egypt in the years to come. With Egypt's population growing by 1.3 million every year, the need for water for basic human needs and growing crops is rising proportionately (Swain, 2008). Demands for water in Egypt are growing rapidly in response to an increasing population and the rising standard of living (Alnaggar, 2003).

Egypt is located in a dry climate zone where rainfall is scarce and the desert covers most of the land. In addition to its fixed Nile quota, a deep groundwater reservoir, which is not renewable and the higher the exploitation rate, the shorter the period of use will be. The water shortage is the main constraint and a major limiting factor facing the implementation of the country's future economic development plans (Allam, 2007). Consequently, water managers in modern Egypt are faced with unprecedented population pressures and alarming levels of water pollution, as well as water resources management in Egypt becomes closely linked with numerous aspects of the national economy and social stability, and at the same time has very direct effects on the health and livelihoods of many citizens (Luzi, 2010). For Egypt, while institutional changes in the Ministry of Water Resources and Irrigation MWRI are visible, still they are not adequate to address the key water sector challenges facing the country. These challenges and weaknesses require a strong emphasis on improving the management of water resources based on well-prepared policies and strengthened institutional arrangement. In the respect of current status in terms of challenges and opportunities, water resources management should be prepared within the context of integrated framework that takes into account the interdependencies among stakeholders and it also helps in establishing improved coordination among institutions consistent regulations and policies (Alnaggar, 2003). In essence, the challenges faced by the Government of Egypt necessitate changes in the way water is currently allocated and managed (Wagdy 2008).

### *2.1 Water Resources Management in Egypt: Review of Water Resources Policies and Plans History*

- Period 1929- 1960's: In 1929, an agreement between Egypt and the United Kingdom, on behalf of Sudan, was signed to ratify the historical Nile water rights for each country. In 1933, the Government of Egypt (GOE) implemented a water policy designed to benefit from the extra storage of the Nile water upstream from the old Aswan reservoir after its second elevation. That policy aimed at cultivating additional 160,000 ha in Lower Egypt and converting 208,000 ha from basin to permanent irrigation, along with the establishment of public open drains in the permanent irrigation areas (Allam, 2007). In 1948, GOE presented a memorandum to the cabinet showing that after 1950 there would be a pressing need to find extra water resources. The memorandum recommended several Upper Nile projects to increase the river flow and to avoid flood hazards (Allam, 2007). Land reform in the 1950s rendered the Ministry of Agriculture an important partner in water allocation planning. The growing emphasis given to the industry and services sectors also increased the influence of the corresponding ministries in water policy processes (Luzi, 2010). After the 1952 Revolution, the High Aswan Dam (HAD) project was presented to the Government and was approved. In 1959, an agreement between Egypt and Sudan had been reached for the optimal use of Nile Water as an integral part of 1929 agreement (Hvidt, 2000).
- Period 1970-1980's: In Egypt, water planning is said to have started in 1933 when a policy was formulated to use the additional storage capacity made available by the second heightening of the old Aswan Dam and the Gabal El-Awlia Dam in Sudan. This plan introduced programmes for land-reclamation, conversion of some basin irrigation to perennial irrigation, and increases in the areas under rice cultivation. This policy was first revised in 1974 and again in 1975 when a new plan was drafted to accommodate the extra volumes of water resulting from the erection of the High Aswan Dam (Hvidt, 2000). In 1975, the Ministry of Irrigation (MI) established a policy aimed at rebalancing the water status through the rationalization of crop water applications, in light of studies and

field experiments. The additional demands were to be satisfied by the reuse of drainage water, expansion of groundwater utilization especially in the Nile Delta region and the optimal use of rainfall on the northern coast. In 1977, the Ministry of Irrigation began preparing the National Water Master Plan (NWMP) in collaboration with the German Development Bank (KFW) and UNDP. The NWMP aimed at setting plans to satisfy water demands over a period of 20 years (1980–2000) (Allam, 2007). In 1981, the first attempt was made to create a master plan for all water use in Egypt. It was carried out in the early 1980's under the auspices of UNDP and the International Bank for Reconstruction and Development (IBRD). The Ministry of Irrigation at the time pointed out the objective to be achieved by this effort for introducing new scientific techniques, using mathematical models to design future plans for water development, and for ensuring efficient use of this resource. The resulting plan, the "Arab Republic of Egypt Master Plan for Water Resources Development and Use" was a first step which is intended to lead to improved planning capabilities within the sector. The main objective of the plan was to implement planning tools which will make it possible to plan the development and use of water resources with greater precision in the future (Hvidt, 2000).

- 1980-1990's: In 1982, The Ministry of Irrigation reset its water policy according to the results of the NMWP. The new policy showed that extra water was needed to satisfy future water demands. The policy showed that this additional water could be secured through Egypt's share in the first phase of the Jonglie canal and to expand drainage water reuse practices. However, in 1994, Ministry of Water Resources and Irrigation (MWRI) and the General Authority for Land Reclamation prepared a comprehensive and ambitious plan intended to expand the country's agricultural horizon by 1.28 million up to year 2025.
- 1990-2000's: The government launched three mega-projects to increase irrigation on "new lands". They are located in the Toshka area (New Valley), on the fringe of the Western Nile Delta, and in the Northern Sinai. These projects all require substantial amounts of water that can only be mobilized through better irrigation efficiency on already irrigated "old lands" as well as the reuse of drainage water and treated wastewater (Water, 2013). In October 1997, MWRI prepared a draft of 'Water Resources Strategy of Egypt Until 2017'. Hence, the strategy also analyzed the projected water balance in year 2017 through the completion of the first phase of Jonglie canal, an increase of groundwater utilization, water reuse practices, and a reduction of the areas of high water requirement crops (Allam, 2007). Until today, none of the Nile basin countries has endorsed the 1959 agreement between Egypt and Sudan. However, there had been many technical cooperation programs between Egypt and these countries. At present, both the Council of Ministers and the Technical Advisory Committee work to set up the legal framework necessary for regional cooperation among the Nile Basin countries (Allam, 2007). In 2003, MWRI started a program to support improved environmental and water resources management focusing on the decentralization and integration of water resource management at the irrigation district level. Introduction of Integrated Water Management Districts (IWMD) is adopted as a strategic solution. A typical IWMD is an independent government irrigation operation and maintenance organization, at the district level, that has sufficient manpower, material, and financial resources to operate and maintain all water resources under its jurisdiction. However, the implementation of an integrated water management at the district requires integration of staff, facilities, stakeholders, information, users, and water resources. Moreover, an effective information management is recognized as a must for appropriate operation of IWMD along with relevant databases as supportive tools (Wagdy 2008).

## *2.2 Water Resources Management in Egypt: Water Policy Actors and Water Sector Governance*

Water resources management in Egypt depends on a complex set of infrastructure along the entire length of the river. The key element of this infrastructure is the Aswan High Dam that forms Lake Nasser. The High Dam protects Egypt from floods, stores water for year-round irrigation and produces hydro power. The dam stores more than one and a half the average annual flow of the Nile River, thus providing a high level of regulation in the river basin compared to other regulated rivers in the world (Hvidt, 1995). Water resources management in modern Egypt is a complex process that involves multiple stakeholders who use water for irrigation, municipal and industrial water supply, hydropower generation and navigation. In addition, the waters of the Nile support aquatic ecosystems that are threatened by abstraction and pollution. A key problem of water resources management in Egypt is the imbalance between increasing water demand and limited supply. In order to ensure future water availability coordination with the nine upstream Nile riparian countries is essential. The Nile Basin Initiative provides a forum for such cooperation and in order to insure more effective management of water resources and more efficient water use, the MWRI has adopted a policy to increase the participation of water users in water management and in operation and maintenance of the irrigation and drainage system.

Water policy processes in Egypt are very complex as the MWRI's ability to design and implement water development strategies according to IWRM guidelines is limited. The interests of other stakeholders sometimes interfere, and water sector reform has to challenge existing organizational routines and biases (Luzi, 2010).

Actually, policy outcomes regarding different water management issues depend to a critical degree on the way the interests of a wider range of actors are traded off, and actions taken by interest groups during the implementation phase. Moreover, national policies are basically formulated to varying degrees by the President, the Cabinet and the sectoral ministries, as well as the ruling party. However, decision processes at the highest political levels are not very transparent and hard to assess analytically (Luzi, 2010). In fact, three major governmental entities influence the management of water resources in Egypt; which are The Ministry of Water Resources and Irrigation, the Ministry of Agriculture and Land Reclamation, and the Ministry of Housing (Wagdy 2008). The MWRI enjoys a high degree of prestige due to the historic importance of irrigation water distribution in Egypt as MWRI is responsible for managing major activities that are directly linked to the social and economical development. These activities include operation and maintenance of irrigation and drainage networks, implementation of basic infrastructure and pump stations for new agricultural lands as well as survey work for horizontal expansion and other development projects (Alnaggar, 2003). Central government agencies play also a dominant role in water policy processes, due both to the political history and organization of the state and the nature of the country's water supply as stemming from a single most important source. The MWRI has overall responsibility regarding water allocation. In addition, the Ministry of Housing, Utilities and New Communities, together with the ministries of agriculture, environment, health, industry, and local development, form the inner circle of water policy actors. Among the non-governmental actors, donor agencies play a prominent role and the Dutch Embassy, the World Bank, and—formerly—USAID are arguably the most active donors in the field of water resources policy and institutional reform. Business actors maintain also mostly informal or indirect linkages to the water sector, either through personal contacts or through the responsible state agencies.

In recent years, the government has established a number of holding companies as for the management of land reclamation projects in Sinai and the Southern desert. However, these companies remain institutionally and personally linked to the related public sector agencies and their influence as autonomous actors is unclear. There are only few advocacy NGOs in Egypt that deal with water and environmental issues at the national level. However, NGOs choose mostly to avoid confrontation with state agencies.

Accordingly, different water user groups and the ministries providing services to them have different interests in terms of the quantity, quality, and cost of water (Luzi, 2010). To ensure co-ordination among agencies involved in water resources, three committees have been formed. Two of them, the Supreme Committee of the Nile, headed by the minister of the MPWWR, and the Coordinating Committee for Land Reclamation meet monthly to direct and review different developments plans, as well as to resolve conflicts between ministries. The third committee is called the Inter-Ministerial Committee on Water Planning (ICWP) and was established in 1977 as a part of the Master Water Plan project. ICWP is, as the name indicates a cross-ministerial committee with a strict focus on planning. It has been given the responsibility to set planning assumptions and review development plans (Hvidt, 2000).

The National Water Resources Plan will have to consider all components of Egypt's water resources system and all functions and water using sectors involved. Therefore, one of the essential elements in developing the plan is to create the necessary co-ordination mechanisms to develop consensus on the objectives and implementation of the NWRP between all stakeholders involved in the development and use of Egypt's water resources, both governmental as ministries, regional authorities as well as non-governmental as industry, water users, organizations (Alnaggar, 2003).

Another example of the 'governmental politics' pattern is the debate on industrial water pollution that involves inter-ministerial interest bargaining beyond the control of MWRI planners. Even though the MWRI is ultimately responsible for the provision of good quality water for users in all sectors, and is therefore enormously interested in maintaining acceptable quality levels, other actors' positions and actions in both the planning and implementation of quality control measures have so far impeded the adoption of effective pollution control regulations. The divergence between the positions of MWRI and Egyptian Environmental Affairs Agency EEAA regarding the reuse of municipal wastewater also illustrates the 'governmental politics' type of policy-making (Luzi, 2010).

In fact, five main socio-economic sectors are dependent on the available scarce water resources for their development; namely the agricultural, industrial, municipal, navigation, and power generation sectors. The cultivated and cropped areas have been increasing over the past few years and will continue increasing due to the government policy to add more agricultural lands but although the water policies of the 1970 and early 1980's gave a significant advantage to new lands development, yet, recent changes in price and other policies particularly the reduction or elimination of government fertilizer and energy subsidies place farmers in the new land at a disadvantage.

During the seventies and early eighties of the last century, policies have been directed towards water supply management. At present, integrated water resources management, which seeks an efficient blend of all available resources (fresh surface water, ground water, precipitation and drainage water) to meet demands of the full range of water users (including agriculture, municipalities, industry and in-stream flows) is becoming an integral part of MWRI's policy vision to meet these challenges. An extensive coordination effort among concerned government institutions and the active participation of water users in planning, management and operation of water collection and distribution systems is required. Integration also necessitates the establishment and enhancement of the legal basis for water allocation, conservation and protection as well as user participation in water management. To cope with these challenges, the MWRI has developed a national policy for increasing water use efficiency; water quality protection; pollution control and water supply augmentation (Wagdy 2008).

An institutional reform process is currently underway in the Egyptian water sector with the goal of establishing a decentralized system that would allow the MWRI to deliver better services more cost effectively, and would create incentives for users to utilize water more efficiently. Decentralization of water management tasks should eventually limit the direct responsibility of the MWRI to water allocation at the level of major canals, and to the design and enforcement of national policies and regulations. Accordingly, Water User Associations (or Water Boards) at the local and branch canal levels will be in charge of local water distribution, operation and management of infrastructure, as well as cost recovery. In fact, the integration of different government services at the local level is another concern addressed seriously in the institutional reform (Luzi, 2010).

A failure of the institutional reform would not only mean that financial resources currently spent on local-level irrigation and drainage services would not become available for other pressing water sector programs as water quality control but also that the quality of water services for the end users could further deteriorate. The willingness to undergo reform is well-established at the level of top management but is less certain among the lower-level MWRI staff. Changing routine behavior within the water sector institutions and dragging along the MWRI staff may be a greater challenge than convincing the farmers to organize themselves into water user associations. In this sense, the water policy outcomes related to the institutional reform process are governed to a significant extent by an 'organizational processes' type of policy pattern (Luzi, 2010).

### *2.3 Water Resources Management in Modern Egypt: Problems and Challenges*

Since the 1970's, water uses in Egypt have exceeded the available resources. Accordingly, the government has provided additional resources by recycling drainage and wastewater, trapping water losses, and with water use rationalization practices (Allam, 2007). However, at present, there are significant challenges to water resources management in Egypt. Beginning with a single source of water the Nile, uncertainties in climate, developments upstream, and population growths have characterized efforts to anticipate potential future water constraints. Actually, future public sector allocation for such high costs presents a heavy and unsustainable burden for the government budget. In addressing the main issues and the way forward, The Minister of Water Resources and Irrigation has stated that the challenges facing the water sector in Egypt are enormous and require the mobilization of all resources and the management of these resources in an integrated manner. This is especially true as the amount of available water resources is fixed, meanwhile water demands continue to grow in the years ahead due to population growth, increased food demand, and expansion and modernization of the industrial base, and improved standards of living (Wagdy, 2008).

In fact, Egypt's water problem cuts two ways: on the one hand a scarcity of fresh water to drink and irrigate crops, on the other, an overabundance of salt water, already rendering farmlands barren, and threatening to drown the low-lying areas along the Mediterranean coast. Coastal erosion, a consequence of both the Aswan High Dam and global warming-related sea rises, is readily observable in Egypt (Golia, 2008). All the lakes suffer the additional burden of fertilizer run-off from surrounding farmland, also the fishing communities have disappeared, and it is also threatened by diminished water quality (Golia, 2008).

As the acceleration of the productivity is the main objective of Egyptian economy, however, this is reached sometimes at the expense of sustainability. The challenge the policy-maker faces is how the development can reduce poverty, but to be made compatible with the maintenance of the natural resources (Radi, 1987). According to United Nations projections, the population of Egypt will grow from 62.3 million in 1995 to 95.6 million by 2026 and will likely reach 114.8 million before it stabilizes in the year 2065. In spite of Egypt using most of its share of the Nile water for irrigation, at present it imports more than half of its food grains. Increasing demand for food in the future will certainly bring further pressure on the scarce water supply (Swain, 2008). However, it is found that in Egypt, despite considerable planning capacities, many water policy outcomes are influenced by developments beyond the control of the water ministry. Water governance is also influenced by top-level strategic

decision-making, conflicts of interest between sectors; enforcement priority given to policies that prioritize political stability or certain privileged interest groups, adding to the intra-organizational resistance to institutional reform. Issues that have emerged more recently, such as water quality or demand management, are subject to interest bargaining between different stakeholder groups in both the planning and the implementation phases (Luzi, 2010).

### 2.3.1 Challenge of Water Scarcity

Egypt is already importing more than 50% of the cereals it consumes. Assuming that Egyptians' population carries on growing Egypt cannot meet its food demand by relying on Nile water for irrigation (Asempa, 2010). Adding to Egypt's precarious water situation, the evaporation from the surface of the long Lake Nasser apparently exceeds the earlier estimated amount. Egypt is already utilizing most of the flow of the Nile and it plans to use even more. The land reclamation project in the Western Desert has even stirred internal tensions in Egypt because those residing in other areas fear their water supplies will be affected. Additionally, Egypt has built several irrigation projects such as the Isna Barrage, Nag Hammadi Barrage, and Asyut Barrage, which will certainly be affected by decreased flow from Aswan (Swain, 2008). It is forecasted that in 2025 the population of Egypt will increase to about 95 million, leading to a decrease in per capita water availability per year assuming that total water availability remains constant. Moreover, developments in Sudan, Ethiopia or other riparian countries could reduce water availability to Egypt (Baldassarre, 2011).

#### 2.3.1.1 Water Supply

The MWRI with its institutions, sectors and organizations have always focused on developing old and new water supplies to satisfy the over-increasing demands as follows:

- The High Aswan Dam HAD [1960-1971]: HAD been built to assist and to accelerate the food production in order to accommodate the accelerated population growth of Egypt. Surface water resources are limited to Egypt's share of the Nile River, together with minor amounts of rainfall and flash floods. High Aswan Dam provides storage to guarantee regulated water supplies (Alnaggar, 2003). HAD intends to protect Egypt against fluctuations and variations in the flow of the Nile and guarantee water supply for municipal, industrial and agriculture uses; to expand the cultivated area by and extend it beyond the limits of the Nile valley. HAD intends also to expand farming by multiple cropping along the Nile valley since irrigation water would be available throughout the year; to generate 10 billion kWh of electricity per year; to improve navigation conditions below the dam as well as to develop fishing in Lake Nasser and to return the HAD into a tourism attraction (Kliot, 1994).
- Upper Nile Projects: According to the Nile waters agreement 1959, joint projects are to be executed to increase the yield of the Nile that will be divided equally between Egypt and Sudan. Three projects in particular had been scheduled to be implemented. These are: Jonglie Canal, Bahr El-Ghazal development and River Sobat-Machar Marshes. The Upper Nile water development projects will add approximately 18 billion m<sup>3</sup> /yr to the present flow of the Nile, equally divided between the two countries (Alnaggar, 2003; Elarabawy, 1998).
- Rainwater: Within the western part from Alexandria city to El-Sallum, the northern coast receives a modest amount of winter rainfalls to the east in El-Arish region then rises up again to eastern of El-Arish at Rafah, northeast Sinai. The water available is merely sufficient for pastoral purposes, to some extent for seasonal agriculture especially in excessively rainy years, for cultivating some olive and fig in the western and peach in the eastern zones. Coastal sand dunes and valley sediments that receive rainfall accommodate shallow wells for drinking water. In Sinai, some reservoirs have been constructed to collect heavy rain falls in the valleys (Abdel-Shafy, 2002).
- Ground Water: Ground water exists mainly in the Nile Valley and Delta, the Western Desert, and Sinai. The largest ground water deposit is the giant Nubian sandstone aquifer underneath the eastern part of the African Sahara, and is shared between Egypt and four other countries. Ground water in the Nile aquifer cannot be considered a separate source of water. The aquifer is renewable only by seepage losses from the Nile, irrigation canals, and drains; and percolation losses from irrigated lands. In these aquifers, the ground-water potential depends greatly on subsurface drainage (Alnaggar, 2003; Elarabawy, 1998). The major groundwater aquifers stretch in the western desert and Sinai, beneath and west of the Delta (Natroun Valley and Cairo-Alexandria desert road), Salheyia, beneath Upper Egypt. This water is renewable because it originates from the leakage of Nile and drainage waters. The percolation of excess irrigation water and extraction of groundwater in the rest sectors of the Delta largely govern the process (Abdel-Dayem, 1994). On the other hand, fresh water within the northern frontiers of the Delta plays an important role in safeguarding the region against Mediterranean Sea saline water. Moreover, rice cultivation within the northern sector plays an effective role in protecting fresh

groundwater. The quality of groundwater is so far evaluated on an intermittent basis, predicting signs of pollution within a 30-meter depth (Abdel-Dayem, 2011). It is worth mentioning that these groundwaters are of non-renewable fossil origin. Thus, bearing in mind the rights of next generations, optimizing their use in an economic way is very important (Abdel-Shafy, 2002).

### 2.3.1.2 Water Demands

Demand for water in Egypt is growing rapidly in response to an increasing population as well as to the rising standard of living that led to higher crop intensities and horizontal expansion. The logical sequence in water resource management is to examine the present demand of water for all purposes, to determine how the demand in various sectors will be affected by growth then to project what the water demand will be in the short and in the long term future (Alnaggar, 2003). Various demands for freshwater are exerting excessive pressure on the available water supply as follows:

- Agriculture: The agricultural sector is the highest freshwater consumer as cropping patterns are a crucial factor in water resources management, especially under the free-market policy. The prediction of future water requirements depends upon the best estimation of cropping patterns. The combined effect of rapid population growth and an increase in living standards has led to an increase in the demand for food. The Ministry of Water Resources and Irrigation (MWRI) in Collaboration with the Ministry of Agriculture & Land Reclamation have planned an ambitious program for reclamation (Alnaggar, 2003). However, irrigation agriculture mainly consumes the bulk of the available water supplies. Despite losses of agricultural land to urbanization, the cropped area statistics indicate a very modest increase during the last decade due to an increase in cropping intensity, complying with the national plan to achieve food security and the distribution of crop areas then has not change significantly during the last decade (Wagdy 2008; Alnaggar, 2003).
- Municipal and Industrial Water Demands: Estimation of the municipal water use depends on population growth rates, the consumption in liter/capita/day, and distribution system losses expressed as conveyance efficiency estimation of municipal water use.
- Navigation and Hydropower Water Use: From February to September, water released from the High Aswan Dam (HAD) for irrigation, municipal, and industrial purposes is sufficient to maintain the required navigational draft in the Nile.
- Outflows to Sea: Water enters the system at the High Aswan Dam and flows to the sea as freshwater through the Rosetta and Damietta branches, and as drainage water through the main drains (Alnaggar, 2003).

### 2.3.2 Challenge of Renaissance Dam

The most prominent challenge is that Ethiopia is proceeding with the implementation of the Renaissance 'El Nahda' Dam that represents the greatest threat to Egypt's water security, in light of the available information on the Renaissance Dam which is located on the Blue Nile in western Ethiopia (Al-Hayat, 2013). Actually, Egypt's share of water has not changed since the fifties despite a growing population and high rates of population development in Egypt, accordingly the dam can be a disaster disrupting Egypt's development map (Essa, 2013). In fact, the Nile River has been the source of political tension among three of its major riparian countries; Egypt, Sudan and Ethiopia (Swain, 2008). Egypt and Sudan are playing a central role in the dispute over the Nile as they know they can no longer ignore the thirst for water (Asempa, 2010). However, the major challenge to Egypt's Nile water access comes from Ethiopia which having a growing demand for developing water resources to increase the country's agricultural production as Ethiopia is experiencing more frequent and drastic shortfalls of food production that lead to ever-increasing food imports. Thus, Ethiopia is serious about achieving self-sufficiency in food production at any cost (Swain, 2008). Energy is the other key issue. It is estimated that Ethiopia needs around 20% more energy a year and less than 0.2% of its hydropower potential is exploited. Addis Ababa has an ambitious plan to use the Blue Nile to transform the country into a hydropower giant (Asempa, 2010). Accordingly, Ethiopia is serious about maintaining more Nile water for its own use. However, any irrigation project in the Ethiopian highlands is certainly going to have adverse effect on the Nile's water supply in the downstream. In summary, Ethiopia poses a larger and more complicated problem for Egypt's water security than Sudan (Swain, 2008). Renaissance Dam with such specifications has catastrophic effects on Egypt and the dam will cause Egypt to sustain a huge water share deficit, causing the end of agricultural expansion, a possible reduction of the currently cultivated area, an increase of salinity in the northern part of the Delta in such a way that prevents cultivation of those lands and their fallow lands, damage to potable water stations, the collapse of canals and drains, and environmental destabilization in the northern part of Egypt (Alexandria and the north coast). Furthermore, it is possible that this dam would prevent water from reaching the coastline, affect navigation on the river and cause a reduction by an estimated 20% in the electricity production generated from the High Dam in Aswan. Moreover, if

the Renaissance Dam were to collapse, an area of 16-20 square km stretching from the site of the dam all the way to Khartoum would be flooded and destroyed. Furthermore, a huge influx of water would pour into Lake Nasser. This could lead to the collapse of the High Dam in southern Egypt, if the lake was already full, given that there is no mechanism for draining excess water from the lake. In that case, this would destroy all of the cities located in the vicinity of the dam and extending to Cairo, and would flood the Delta. Despite all the challenges, the Egyptian way of dealing with the developments has not matched the severity of the pending dangers. All intensive Egyptian efforts in this regard have been an exercise in futility as they failed to placate the Egyptian concerns regarding the 'Framework Agreement', particularly given the fact that the negotiations about it were postponed more than once, while the upstream countries are speeding toward ratifying it without taking into consideration the interests of the downstream countries. Egypt did not even receive any detailed information in regard to the structure of the Dam until Ethiopia announced its construction in April 2011 (Al-Hayat, 2013).

The Ethiopian government claimed that the dam would not affect Egypt's quota of the river. However, it is known that Ethiopia led the other Nile Basin countries into signing the Co-operation Framework Agreement in May 2010 with the announced aim of obtaining fair distribution of the river quota between the different Nile Basin Countries (Selamawit, 2013). The Nile Cooperative Framework Agreement must clearly recognize Egypt and Sudan's historic share of the Nile waters. Yet Egypt agreed to participate in the negotiations, alongside Ethiopia, and other countries. However, Cairo's strategy was to spin out, and thus delay the process; as with so many countries involved, it would be hard to reach consensus (Asempa, 2010). As Essa (2013) noted, it is the right of Ethiopia to look for its development, but it should be without harming others. That's why it is important to support the common areas for integrated development with the Nile Basin countries through the exploitation of mutual possibilities of each African country in the field of cooperation of health, education, culture, agriculture, industry and trade. It is crucial also to coordinate all efforts, sending a strong message to African countries that Egypt will return to Africa (Essa, 2013). In fact, this problem should be resolved between the two countries by working on reaching a new agreement, enabling Ethiopia to create its dam without adversely affecting the quota of the downstream countries of Egypt and Sudan. It is hoped that the Presidency will hastily settle this conflict with Ethiopia by signing an agreement committing Addis Ababa's government to preserving Egypt's quota of the Nile water and having the project implemented under the supervision of Egyptian experts, especially given Egypt's good experience in the field. Similarly, Egypt should speedily carry out other significant projects on the river in co-operation with other upstream countries with the aim of enhancing Nile resources, such as the Jonglei Canal project with South Sudan (Selamawit, 2013). In the face of potential armed conflict and regional instability, the Nile basin countries, in cooperation with the international community, have recently begun working for basin-wide cooperative solutions which could further reduce tension over scarce water resources and facilitating effective and lasting cooperation in the Nile basin. It is crucial not only for the region, but also for global peace and development, to achieve success in bringing the countries together in the basin for efficient benefit sharing of resources of this important river (Swain, 2008). Egypt cannot remain isolated while Ethiopia is striving for development. It's the right of all Nile Basin countries to pursue their development. Yet, this right is governed by avoiding harm to any neighboring countries' interests (Taha, 2013).

### 2.3.3 Challenge of Pricing Water as a New Concept of Water Use

Water is absolutely a human right, but at the same time, how to manage it, is very important all over the world, as there is a continuous innovation for better and efficient new concepts of water use. Technology alone cannot close the growing gap between water demand and water supply. Globally, all developed countries established environmental and economic regulations in water quality, pricing and customer services (Rezaee, 1999). In matters of pricing, whoever has to take the water from the original water source, bring it to the plant or the city, take away the used water, or treat it; in other words those services must be priced and be paid for as well as a polluter-pay, user-pay principle should be applied. Likewise, people who pollute water, making it unusable for their downstream neighbors need to pay the full price for it (Andelman, 2010). Actually, water should be perceived as more valuable than oil today. However, because it is not priced, in many countries it is still considered politically taboo to talk about pricing water, yet there is a lot of waste in how water is managed. The fact is that pricing water below its true cost will lead to inability to meet tomorrow's demand. Accordingly, it is crucial to get countries to collaborate with each other around the proper management of river basins. Just as private companies invest in energy, some also invest in water and sanitation. The price controls that are impacted can be linked with performance standards in other ways (Andelman, 2010). The challenge is that water has been traditionally viewed as a free commodity in Egypt, which resulted in a very high domestic water consumption as consumers don't use water rationally especially in areas where the water systems are well functioning. In fact, the excessive government subsidies encouraged the water wasteful practices because water price doesn't reflect the actual cost

for providing it. Obviously, it is also very important for the Egyptian authorities to learn from other countries experience in water resource management and to be exposed to the new concepts of water use (Elarabawy, 1998). Water privatization allows for a voluntary transfer of rights between buyers and sellers under adequate protection for other affected parties in order to ensure efficient use and conservation of available water resources. In other words, privatize water authorities tend to provide economic incentives for both suppliers and customers of water to achieve efficient management of water resources through establishing a competitive multi-supplier framework to demonstrate the efficiency of water allocation and distribution. So, it tends to create water transmission systems operated by private regulated firms that sell their services to water supply companies and customers. At the same time, the water transmission systems are subject to quality control, pipeline-channel network specifications and price constraint (Rezaee, 1999).

### 2.3.4 Challenge of the Fragmentation of Agricultural Land Holdings

Most of the studies concerned with the potential global and local effects of GATT showed that the benefiting countries from the agreement are, in general, the most exporting ones, and that the countries whose food imports are more than their exports, as the case of Egypt, will suffer much more (Siam, 1994). In fact, holdings fragmentation is one of the main issues that threaten the agriculture in Egypt, particularly in the old land in the Nile Valley and Nile Delta. This is due to its direct impact on agricultural production efficiency, marketing, water use efficiency, and even on the income of farmers who became among the lowest income groups nationwide. The average holding size in the 1920s and 1930s was more than 2.4 ha. After the agricultural reform law, the average holding decreased to about 1.5 ha. The present average holding size at the national level is about 0.8 ha. Without the animal and poultry wealth that provides extra income, farmers would not be able to cover their living expenses. More fragmentation will increase the difficulties of irrigation management and thousands of farmers may leave their cultivated land looking for a better income in urban centers. Farmer's immigration will have serious social, economic and security consequences (Allam, 2007). For Egypt, the estimated economic losses resulting from this agreement are about 180-236 million dollars/year showed that in the event of the full deregulation of international trade, international prices will increase by about 16%, and on the level of consumer goods, a high increase will occur in the prices of dairy products followed by sugar then wheat and rice (Allam, 2007). So far, the government has offered few incentives to encourage farmers to manage their agricultural requirements in a way that emphasizes sustainable water use, either by saving water or maintaining water quality. While drip irrigation can provide a quick fix to the issue, yet the installation and the maintenance costs are unaffordable for the average farmer (El Feki, 2013).

### 2.3.5 Challenges of Water Quality and Climate Change

With the steady increase of population and the continuous expansion of urbanized areas, pollution issues have increased too. One of the greatest water related challenges facing Egypt is the pollution of its surface and ground water resources from agricultural, domestic and industrial sources. The cost of environmental degradation due to water quality deterioration is relatively high with serious health and quality of life consequences. Although monitoring water quality of the Nile system started as early as the 1980s, the complexity of water quality management still required the development of other mechanisms including policies, institutional and governance arrangements, infrastructure for monitoring and analytic laboratories, awareness and skilled human resources (Abdel-Dayem, 2011). The closed water system of the country makes it more vulnerable to quality deterioration in a northward direction (Abdel-Dayem, 2011). It was also found that the level of bacteria is higher than what is permitted for both municipal and irrigation purposes. Control of the groundwater withdrawals, especially in the Northern oases and Siwa oasis, is necessary in order to prevent the deterioration of groundwater quality (Allam, 2007). Contamination arises from both point and diffuse sources. Inadequate industrial and domestic wastewater treatment plants and the rapid increase of the population and industrial activities have created significant pollution problems with serious health implications (Alnaggar, 2003). The severity of water quality problems in Egypt varies among different water bodies depending on the flow use pattern, the population density, the extent of industrialization, the availability of sanitation systems as well as the social and economic conditions (Wagdy 2008). The poor quality of drinking water is of great importance since the sources of raw water for many areas have become increasingly polluted. Therefore, it requires more sophisticated treatment to produce drinking water of adequately quality. In addition, water treatments units are not always functioning properly as a result of lacking maintenance and proper operation. Even when water treatment is satisfactory, drinking water is sometimes contaminated in leaking distribution network, which are infiltrated for example by sewage (Wagdy, 2008). In addition, despite of the flourishing fish production in Egypt, only 17 species remain as of 1995 out of 47 species which used to be available in 1948 (Wagdy 2008).

In fact, the MWRI cannot solve the pollution problem alone, but needs to collaborate with different stakeholders including the polluting sectors such as industries, agriculture, and municipal water users. However, water quality control is not generally a top priority in the respective ministries, and their departments dealing with issue of water quality may lack full internal support (Luzi, 2010). At present, the Egyptian industrial managers and engineers are ill equipped to respond to the growing concern and misgivings about industrial pollution. Neither their academic, nor their on-the-job training have provided them with knowledge and experience necessary for identifying and dealing with environmental problems (Abdel-Dayem, 2011). In an initiative to contain water pollution without confronting the business interests of the industries, the Egyptian Environmental Affairs Agency EEAA supports efforts to improve the capacity of industrial plants for wastewater treatment. However, the Ministry of State for the Environment itself is also considered a still relatively weak actor in the water sector by many observers. In summary, decisions regarding water quality control are very much subject to bargaining over stakeholder interests, both within the government and between the government and water users (Luzi, 2010). The anticipated environmental deterioration that may take place in the northern lakes should be closely monitored and evaluated (Allam, 2007). As for the challenge of the climate change, in recent years, a large part of the scientific community has made efforts analyzing the impact of projected climate change on water resources and proposing adaptation strategies. In this context, a number of studies analyzed the effects of climate change on the hydrology of the River Nile Basin (RNB), the world's longest river. In fact, the RNB could be vulnerable to water stress under climate change because of the limited water availability and the increasing demand for water from different sectors (Baldassarre, 2011). Furthermore, climate change is likely to affect water availability to Egypt, although the direction of change is uncertain. Some studies foresee a decline of up to 70 percent in Nile water availability, while other studies project an increase in Nile water levels by 25 percent (El-Raey, 2009).

### 2.3.6 Challenge of Inadequacy of Legal and Institutional Framework

As Andelman (2010) noted, there is no juridical framework anywhere as there is an international convention that has been signed but not yet fully ratified in many countries (Andelman, 2010). Actually, there is no single overarching water resources law in Egypt. The main laws of relevance for water resources management include laws about irrigation and drainage on the one hand, and laws to protect the environment on the other hand. Among the irrigation and drainage laws are the Law 12 for the year 1984 for the Irrigation and drainage, and Law 213 for the year 1994 for farmer participation and cost sharing. However, the current applicable laws governing the government's control of water resources and related installations are incapable of meeting of the government's needs in a manner consistent with its policy reform and economic plan. Therefore, it has become necessary to formulate new rules and amend current laws (Alnaggar, 2003). Actually, there is a crucial need for new laws to protect the resources and to regulate water uses. It is also necessary to enhance the capacity of the existing laws to face the continuing threat on water and watercourses. There are actually lots of legislative concerns such as the weakness of laws and the penalties for transgressing these laws that must be made harsher, thus emphasizing the government's role in both monitoring and executing punishment. Moreover, law number 48 f or 1982, regarding the required standards of pollution of the disposed wastewater to the watercourses, exists actually only on paper most of the time. Suitable health and environmental specifications and guidelines for recycling the agricultural drainage and treated wastewater in different activities are not also well defined (Allam, 2007).

Concerning the institutional framework, there is a real need for developing the institutions engaged in water resources management, in order to be able to face the great challenges of water shortage and increasing water demands. Coordination among the involved institutions as well as decentralization of the decision-making processes is becoming essential. These institutional concerns seem crucial to overcoming the inadequacy of the existing institutional framework such as the lack of sufficient coordination between MWRI and other ministries engaged in the water management, adding to the fact that decision making process in MWRI goes through different levels in a very centralized fashion. Since there are lots of declared ministries that deal with water resources, including the Ministry of Water Resources and Irrigation, the Ministry of Agriculture, the Ministry of Interior, the Ministry of Foreign Affairs, the Ministry of Environment and the Ministry of Health, adding to other stakeholders such as the Ministry of Electricity and Energy and the Ministry of Industry and Foreign Trade that also play an important role, as water is used for generating electricity, and is also an essential component in industries like cement, ceramics and textiles, accordingly in a centralized system, what would be expected is cooperation across the board between the multiple ministries in charge. However, it is quite different in Egypt's case as the mandates and objectives of each ministry are so different that, while one ministry may push for a new approach that would result in sustainable water use, another will often vehemently opposes it, although they promised cooperation. Moreover, in spite of the heavy burden carried out by the district engineer in MWRI,

many engineers do not accept this job, as its rewards are not equivalent to the time and effort needed (Bell, 1998; El Feki, 2013).

### 2.3.7 Challenges of Lack of Public Awareness and Unreliable Information

Lack of Information is also another challenge of water resources management as Egypt lacks the necessary data in various sectors, especially water. The only measured resource is the Egypt Nile water quota downstream HAD. There is no accurate measurement and the available measurements are both limited and for only a few elements. There are also usually done on distant intervals, thus it is not possible to accurately know the agriculture water uses in the different regions. In addition, there is no accurate information available on municipal and industrial water uses or on the losses of the distribution network. Moreover, the inadequate information dissemination and communication among the different institutions and stakeholders increases the difficulties of the water distribution process, and constraints the efforts for developing comprehensive water policies and plans (Allam, 2007).

Concerning the lack of public awareness, technology alone cannot close the growing gap between water demand and water supply. Globally, all developed countries discovered the vital function of information transfer as the public must be informed through religion lessons, films and T.V broadcast, newspaper, adding to an active role for NGO's (Rezaee, 1999). Moreover, in the cities and urban areas, the appearances of extravagance in water use are considerable (Allam, 2007). Accordingly there is a crucial need for a public awareness program for informing the public, through different channels, with the role of the MWRI in water management, its major achievements in that field, and proposed and nearly accomplished projects as well as propagating the significance of water saving in irrigation and domestic uses by demonstrating water saving consequences to people, thus, advocating a new culture of water saving among the whole society. It is crucial for popularizing environmental issues related to water resources utilization and future impacts that might result from specific new water use and saving technique. It is also crucial for demonstrating, through media and in the parliament, a simplified version of the water resources policies and its associated strategies as well as MWRI future plans to execute these policies.; achieving public participation and commitment of water policies and programs, adding to increasing the knowledge of people about new technologies in farm irrigation, and domestic uses to conserve water for future development (Alnaggar, 2003).

### 2.4 Water Resources Management in Egypt: Analysis of the Situation

After shedding the light on the main problems and challenges of resources management in Egypt, it is very important to highlight the economic effects of water shortages on the Egyptian society as a whole as it will lead to agriculture area reduction and to gross farm loss that will in turn lead to national income loss as well as private income loss (Kliot, 1994). However, there are simply two main ways to match demand with supply; either by reducing demand or by increasing supply. In spite of the increasing scarcity of water, however, there are virtually no indications of attempts to reduce water demand in the three main water-consuming sectors; agriculture, municipal, or industrial. In the outlined water plans, there is a "supply bias", a strong emphasis on expanding the supply either by getting larger volumes of water into the system as the Jonglei project, or by optimizing the operation of the system as greater groundwater extractions and reuse of drainage water (Hvidt, 2000). As was demonstrated, water resources management in Egypt is actually facing lots and variety of challenges that can be grouped basically in the deterioration of water quality; growing demand-supply gap; inter-regional waters allocation problems; inadequacy of governmental investments; poor cost recovery and operational performance; excessive government involvement and bureaucratic control. Accordingly, there is a clear shift from water abundance to water deficit. Whereas the supply situation in Egypt has been characterized by abundance, at least up to the year 1988, the system is now in a process of slowly transforming itself into a water deficit system, especially after shedding the light on the challenge of Ethiopia Renaissance Dam. Accordingly, the importance of international co-operation is increasing as the international aspect is a crucial factor in Egyptian water planning. Since Egypt's water resources are mostly produced outside the country (upstream of Lake Nasser), the planned expansion of supply has to be undertaken in collaboration with upstream governments. Accordingly, this would place Egypt in a very difficult planning situation as it simply does not possess control over the speed of the implementation of the water conservation projects along the White Nile. Yet, Egypt will increasingly come to rely on the implementation of these projects. There is also a crucial need for establishing priority to non-agricultural uses of water. A main function of the water resource planning, thus, is also to specify the size of the reclamation effort because the speed and size of the land reclamation effort is determined by the outstanding amounts of water (Hvidt, 2000). Moreover, environmental issues have become of great concern because the water supply system relies heavily on re-use of the waste and drain water. There are lots of urgent issues to be addressed such as salinity from agriculture; water pollution from municipal or industrial use; and potential groundwater contamination. In

addition, there is a significant lack of detailed information concerning the capabilities and the actual functioning of the planning procedure among the various sectors participating in the water resource planning. The lack of adequate data seems to be a constraint on the planning effort. No accurate figures exist concerning municipal and industrial use, or concerning pollution control, actually the availability of reliable information data on various water quality parameters are basically non-existent (Hvidt, 2000). Moreover, the delayed implementation was noted as lots of projects to rehabilitate and improve the performance of the overall water conveyance systems also run far behind schedule. In fact, this is can be a general phenomenon in developing economies, where a severe constraint on financial resources, weak administrations adding to a lack of political commitment, all of which provide an environment which is not conducive to carrying out maintenance and improvement of the systems (Hvidt, 2000; Wagdy, 2008)). There were various difficulties like the slow rate of implementation, weak monitoring and follow up programs, and funding problems (Allam, 2007). All in all, these challenges are in fact emphasizing the urgency for an effective water resource management in Egypt. Accordingly, various policies were planned and started to be implemented by the Egyptian government in order to increase the usable water supply as well as the efficiency of its utilization.

## *2.5 Water Resources Management in Egypt: Water Conservations and Management Practices*

The management of water resources with the escalating population growth rates, a desire for agricultural expansion, and increasing demands on surface water supply, all of which put a great pressure on the MWRI in order to meet all these growing demands with the available limited water resources. There is a crucial need to develop policy reform that will effectively address issues that determine the utilization efficiency, productivity, and protection of water resources in Egypt (Alnaggar, 2003). Challenges facing the water sector in Egypt call for the adoption of an integrated water resources management (IWRM) approach, which integrates all available resources to meet escalating water demands of the different water use sectors (Kandil, 2003). The concept of Integrated Water Resources Management translates these principles into specific guidelines for effective water governance. These include the imperative to plan water resources development on the base of hydrological boundaries, to pay attention to the linkages between water quantity and quality, to consider the various functions of water in different sectors and in different ecosystems, and to fully integrate demand side management approaches (Luzi, 2010). Accordingly, the Ministry of Water Resources and Irrigation MWRI has prepared a National Water Resources Plan for Egypt (NWRP) that focuses on the physical improvements necessary to satisfy the supply-demand imbalance. As well as the National Water Resources Plan which is based on a strategy that has been called 'Facing the Challenge' that includes measures to develop additional resources, make better use of existing resources, and measures in the field of water quality and environmental protection (Wagdy 2008). As an uncertain administrative framework for water resource planning was highlighted, however, decisions are generally taken, investments are made and some degree of maintenance of the system is undertaken. While this indicates that management of the system is undertaken, it provides little guidance as to whether a real planning capacity is present or not (Hvidt, 2000). Recently, MWRI has adopted new integrated water resources policies focusing on three major aspects: demand management, resources development, and environmental protection. Presently, water resources planning focuses on increasing the water availability for all uses from various sources, adding to saving and conserving water quantity and quality, while at the same time sustaining the environment as well as protecting people from water related hazards. As per the National Water Policy till the year 2017, several programs and projects have been carried out by the MWRI for optimal use of the available water resources and water management for sustainable development and these programs will continue till the year 2017. Regarding water quality protection and water quality status, the preventive measures are carried out through the regular assessment of the water quality status and suitability for various uses in addition to laws enforcement to protect water resources against pollution. Moreover, MWRI established and operates a 'National Program of Water Quality Monitoring' in the Nile, canals and drains and Lake Nasser (Alnaggar, 2003). As for supporting the capacity building, education, training, and public awareness, the Regional Center for Training and Water Studies (RCTWS) intends to organize, to strengthen the regional water studies network, to develop an efficient program for advisory services; information transfer activities and applied research findings, adding to offer specialized training programs, workshops, and applied studies focused on integrated water resources management. The program will concern related managers, professional engineers, technicians, and administrative staff, both in Egypt as well as Arab, African and all Regional countries (Alnaggar, 2003). To strengthen the ministry's capacity for awareness raising program the 'Water Communication Unit' was established to publish regular newsletters, media announcements and carry public awareness campaigns to prompt water saving and protection measures. The Ministry launched a public awareness program to inform citizens with the importance of water resources role in the development plans and to invite water users to positively participate in the decision making process. The development of the New National Water Resources Plan is actually almost involving all stakeholders concerned

with the development and use of Egypt's water resources; this is a clear indication that the Government of Egypt has decided that for the future the users need to be formally involved in water resources management. As for the financing concerns, some of the water qualities monitoring programs are financed jointly by the government and international donors (Alnaggar, 2003). On the other hand, regarding the challenging status with Ethiopia, the urgency of mutual Cooperation was seriously highlighted but active discussions are still in process. As being one of the ten countries sharing the Nile water, Egypt is a member in the Nile Basin Initiative that was established in 1999 and also a member in other similar organization and networks in the Arab and Mediterranean regions. Hence, bilateral cooperation with the River Riparian is carried out through joint agreements to develop the river-shared resources and to bring mutual benefits to the region. Egypt, among other countries, intend to realize their shared vision through a strategic action program that comprises basin-wide projects, as well as sub-basin joint investment projects for exchange of experience, and capacity building (Alnaggar, 2003). The strategy can include the storage of water and use of hydropower for groundwater exploitation in the Ethiopian highlands. In addition, Sudan's water resources can be developed for agriculture irrigation and exportation to the other regions. Finally, Egypt can provide financial and technical resources while having a key role in the management of the upstream hydro-projects. The international community can contribute by assisting Egypt with technological advancements to create a more economically viable desalination process. To a large extent, new technology could even reduce Egypt's insecurity over water availability. Active and healthy cooperation among these three major riparian countries of the Nile River—Egypt, Sudan and Ethiopia, will not only ensure improvement of institutional capacities of basin-based organizations, but is also likely to prevent future diplomatic and military conflict (Swain, 2008).

### *2.6 Water Resources Management in Egypt: Future Water Scenarios*

In fact, most of the existing water policies are sensitive to overcome the challenges of sustainable water resources management in Egypt. However, these water policies, unfortunately, still include several questionable issues that are not only compromising the results of these policies, but also their effectiveness. Hence, three scenarios for the future water status in Egypt can be forecasted. The first scenario assumes the continuity of the current water practices without major changes, the second scenario assumes a relative development of the water policies, and the third scenario is ambitious and reflects a radical development in water management practices in Egypt (Allam, 2007). The results of the three scenarios show that unless urgent steps are taken to control the challenges of resources management in Egypt, it will be difficult to maintain Egypt sustainable development. It may be difficult to achieve the last scenario due to the huge financial investment required. Hence, there is an alarming crisis calling urgently for an effective resources management in Egypt.

### **3. Concluding Remarks and Recommendations**

Egypt, as a developing country is facing a crisis in water resources management. Actually in Egypt, the water shortage experience is not related only to increasing demand, but rather also to poor infrastructure and management practices. It has limited access to funding, and infrastructure requires urgent upgrading. The water sector in Egypt is facing many challenges including water scarcity and deterioration of water quality due to population increase and lack of financial resources. The fragmentation of water management and lack of awareness about water challenges are also clear challenging problems (Alnaggar, 2003). Moreover, the organizational processes and actor interest bargaining interfere with the rational design of water management policies, or with the implementation of such strategies. In fact, the conflict of interests and the pressure on the water authorities to produce comprehensive solutions to urgent problems are not likely to ease up in the near future. Hence, bottom-up contributions by water users are essential for the success of water sector reforms (Luzi, 2010).

Accordingly, important steps have been taken in the Egyptian water sector as conveyance infrastructure and irrigation technology has been gradually improved to ensure efficient distribution and utilization of scarce water resources according to ever more sophisticated hydrological models. An institutional reform process has been set in motion to decentralize water management responsibilities to the water users. Moreover, quality issues are addressed by a number of new institutions, and the overall water policy making process has been made more integrative and transparent. Nevertheless, much progress is still needed to improve the effectiveness of the water sector in addressing issues such as pollution control, cost recovery, inter-sectoral coordination, and stakeholder participation (Luzi, 2010). In fact, the participation of all stakeholders at early stages in the planning and management processes has great impacts on the success of the management. In addition, the MWRI has already implemented several steps towards privatizations and these steps required institutional and legal reform in the ministry mandates and domain of activities. Furthermore, technical and financial assistances might be essential at this stage for numerous ambitious programs. Enhancement of the private sector participation in management and operation of the water resources in Egypt is expected to help facing the above mentioned challenges. However,

institutional reform is also needed for water related ministries. Feasibility studies capacity building and training are also key factors to a successful transfer process which turn requires some additional funding (Alnagggar, 2003). Egypt should also refer more seriously to donor countries and international circles to clarify its point of view regarding Ethiopia's challenging status, including Egypt's need for the Nile's waters and its refusal of any projects that reduce its share, especially given that Egypt is under the water poverty line (Al-Hayat, 2013). Moreover, the Nile should not be taken for granted and the pollution of water resources needs to be taken more seriously as industrial sector and farmers should be fined for malpractice and laws need to be implemented or amended to reflect the importance of water (El Feki, 2013).

At the end, the socio-economic aspects of water resources management in Egypt have recently gained prominence as poverty, unemployment and public health concerns. Yet environmental degradation and sustainable development remain among the most pressing challenges of water national planning. The need for effective and innovative water policies is evident in Egypt. Then the proposed strategies increasingly exceed the task of irrigation water distribution as traditionally performed by the Ministry of Water Resources and Irrigation (MWRI) in Egypt. In accordance with global paradigm shifts, the engineering approach to water management is gradually replaced by more integrated policy-making processes taking into account issues of sustainability; efficiency, subsidiary, inter-sectoral policy coordination, and stakeholder participation. Meanwhile, the sustainable scientific cooperation and transfer of information between the developed countries and Egypt can certainly help in the environmental protection issue (Luzi, 2010). In conclusion, the success of water resources management in Egypt is not merely a function of the planning capacity and willingness to reform on the part of the water authorities, but depends on many actors in the water sector and beyond. The relationships between the government, non-state actors, and user groups have to be shaped carefully in order to enhance both the efficiency and legitimacy of water sector interventions (Luzi, 2010).

To have water is your right but saving water is your responsibility. In this context, the following recommendations should be actively adopted (Kotch, 1994; Allam, 2007; Andelman, 2010; Bell, 1998; Luzi, 2010):

- Intensify the government's efforts to reduce the population growth rate.
- Establish an adequate legal framework as empowerment of the existing water use and water pollution laws seems crucial.
- Strengthen the cooperation ties through better cultural, social, economic and political relations with the Nile Basin countries as well as to support the Upper Nile projects, which will increase the Nile water quota, adding to encourage governmental and private investments in the Nile basin countries.
- Increase the governmental and private sector interventions needed to raise the public's awareness of the water scarcity problems, the rationalizations of water use in the domestic and industrial sectors as well as the protection of water resources from pollution.
- Support the role of scientific research to develop new affordable desalination techniques and to introduce new agriculture seeds that have high productivity, high diseases resistance and low water consumption.
- Push forward the decentralization process of water management up to district level but it should be accompanied by serious capacity building programs.
- Establish a well coordinated information system to support decision makers for making an effective water resources management on an environmentally sound basis.

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