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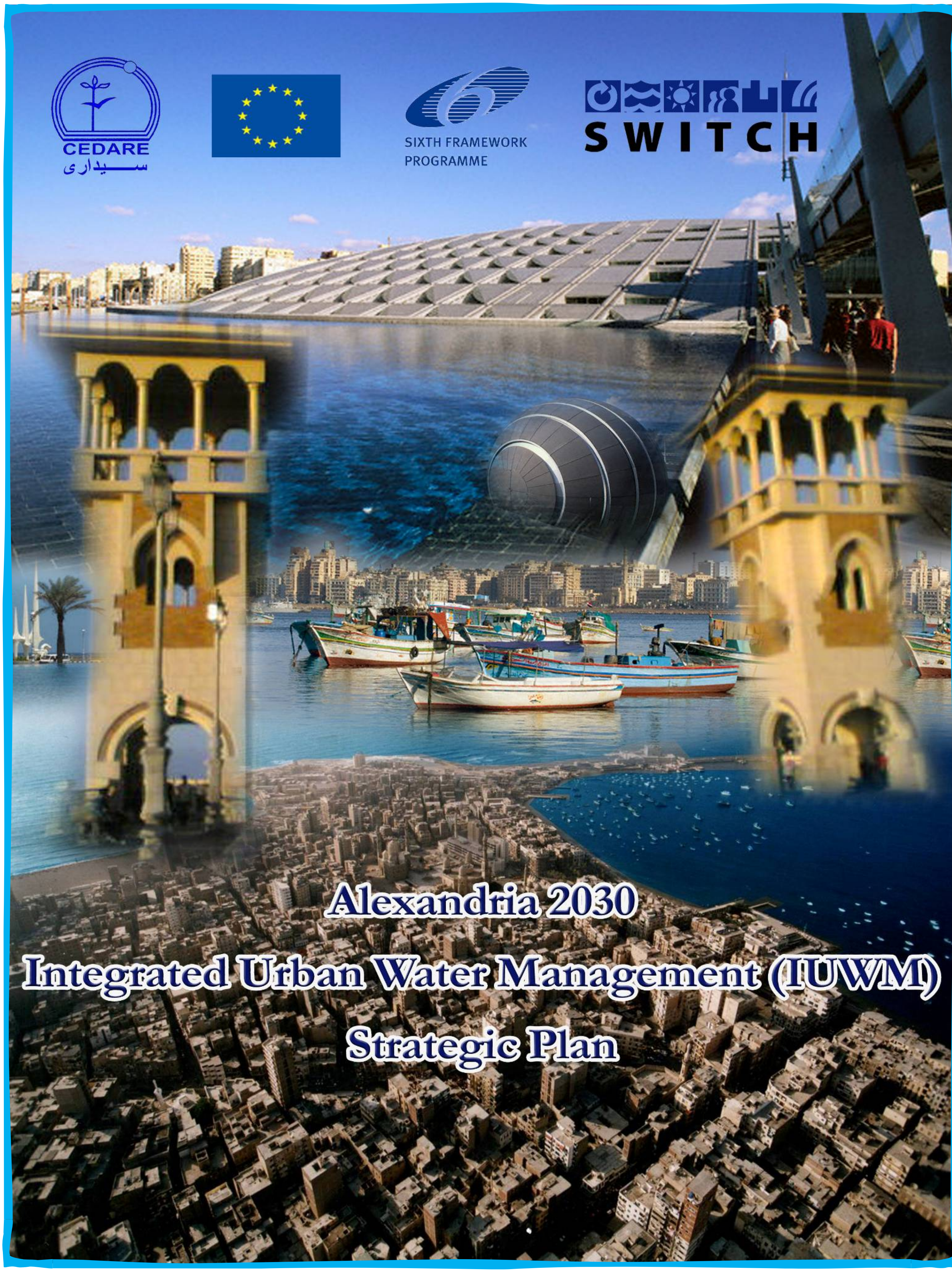
SIXTH FRAMEWORK PROGRAMME

SWITCH



Alexandria 2030
Integrated Urban Water Management (IUWM)
Strategic Plan

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1. Introduction:

Alexandria with 4.0 million inhabitants on the northern coast of Egypt is one of the major cities on the Mediterranean Sea and Egypt's second largest metropolitan. Alexandria accounts for about 5.5% of Egypt's Population and for almost 8% of the country's GDP. It embraces a coast line of 70 kilometers and is home to 40% of Egypt's industrial establishments.

Alexandria is the most downstream city on the longest river in the world, the Nile River, with Egypt being its most downstream country. The Nile River represents the main renewable source of water, supplying over 95% of Alexandria's water demand.

As it resides on the Mediterranean coast, Alexandria is a summer destination, increasing its population in the summer to 6 million people, putting more pressure on the city's water demand. The city receives rainfall of less than 200 mm/year. Storm water either finds its way into sewage systems or drains into the Mediterranean Sea without use, or seeps into the coastal groundwater aquifer through the little-left infiltration areas of the city. Most of the city is covered with potable water supply networks, but many peri-urban and informal settlements lack sewage/sanitation coverage. Most of the city sewage is at least primary or secondary treated; however, potential uses of this treated wastewater are yet to be explored in line with the country's National Water Resources Plan.

Alexandria lays north-west of the Nile delta and stretches along a narrow land strip between the Mediterranean Sea and Lake Maryut (Mareotis). The city extends southwards from the coast to a depth of 2-5Km. in the area of Abu Qir to El Dekhiela, to about 30 Km. near El Ameriya and Burg El Arab. It is linked to Cairo by two major highways and a railroad line. It is one of the most notable summer resorts in the Middle East, for, in addition to its temperate winters, its beaches, with white sands and magnificent scenery, stretch for 140 km along the Mediterranean Sea, from Abu Qir, in the east to Sidi Kerer, in the west.

In the city of Alexandria there are nine low-income, peri-urban areas that remain under or even un-provided with water and sanitation services. Though there are City and Governorate level plans for extending or upgrading services to these areas, the involvement of residents/users from these marginalized areas of the city has, hitherto been very limited.

Population in Alexandria has increased ten times in the last 100 years with pressing demand for new land development including the area around Lake Maryut which is now surrounded by urban and industrial development and drains in the "hot spot" known as El-Mex bay.

The Governorate of Alexandria consists of three individual cities: Alexandria, Borg El Arab City Centre and New Borg El Arab. The city of Alexandria itself is divided into six districts which are shown in fig. 1, three local village units and five sub-village units. The six districts of the urban area are:

- Montazah District, which include five villages in the Abiss region, with a total area of 81 square kilometer.
- Eastern District, which includes two sub-district; namely; El-Raml and Sidi Gaber, with a total area of 49 square kilometer.
- Middle District, which includes three, sub-districts; namely; Bab Sharq, El-Attareen, and Moharrem Beik, with a total area of 36 square kilometer.
- Western District, which includes two sub-districts; namely; Karmoz and Mina El-Basal, with a total area of 30 square kilometer.
- Customs District which has the highest population density and is the smallest Alexandria district with a total area of about 4 square kilometer and includes four sub-districts, namely; El-Mansheya, El-Gomrok, El-Lebban and El-Meenaa El-Sharqee.
- El-Ameriah District, which includes three sub-district; namely; El-Dekheelah, El-Agamee, and El-Ameriah, with total area of 2295 square kilometer for the district.

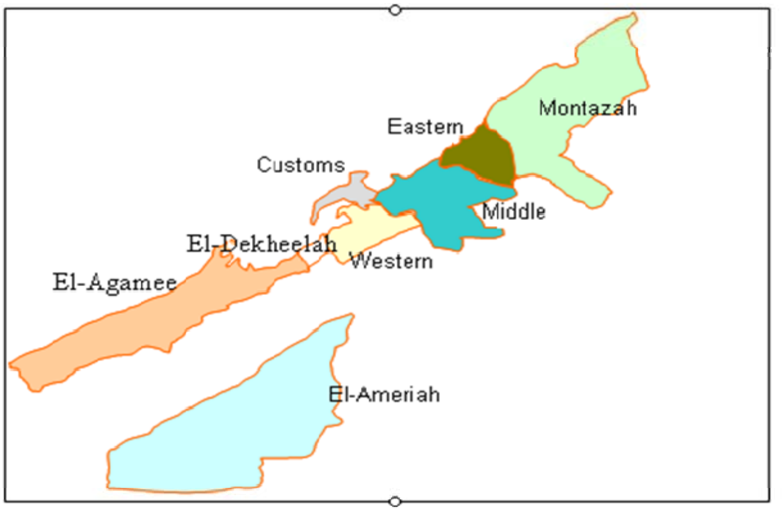
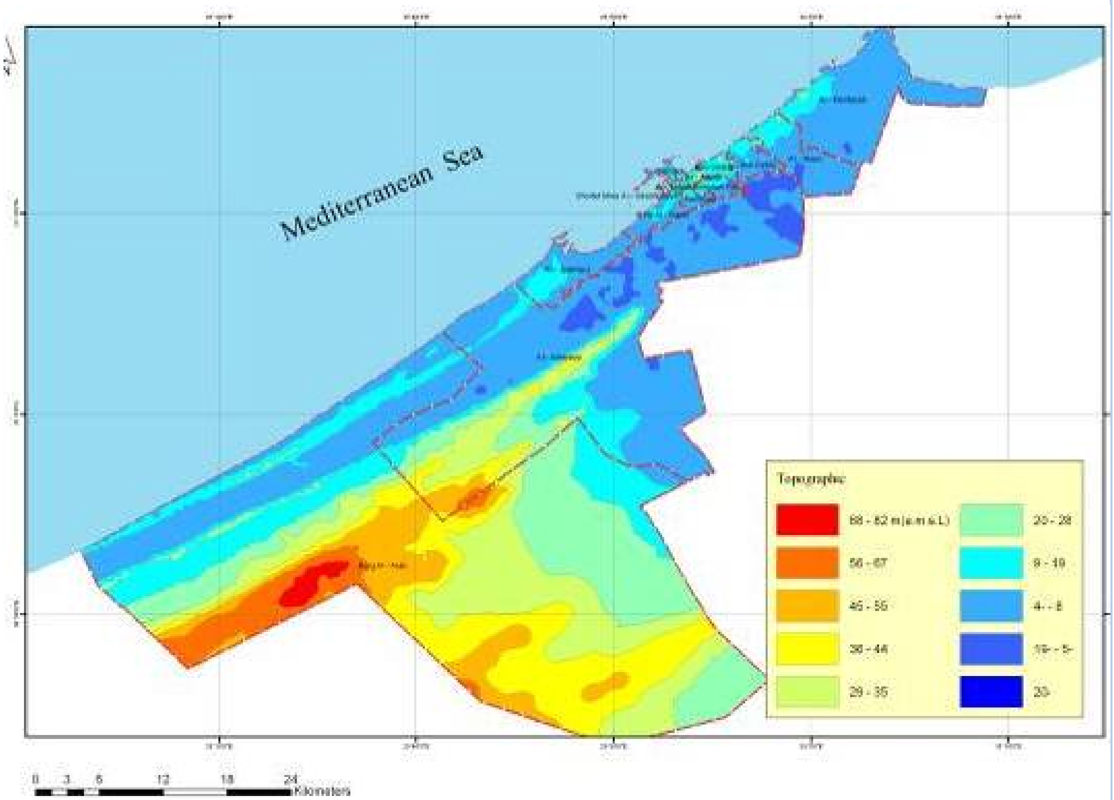


Fig.1 The six districts of the urban area in Alexandria

a. Topography

Fig.2 Location and Topographic Map of Alexandria Governorate



The area is characterized by irregular hills in the southern parts with an elevation from 0 to more than 40 meters above Mean Sea Level and generally slopes towards the Mediterranean Sea in the north. All the drainage systems of Alexandria flow into the Mediterranean Sea.

b. Climatic conditions

The climate of the Alexandria region is one of the mildest of the Mediterranean Sea. It varies from a moderate climate in the north to arid-semi arid climate in the south. The average annual rain is 169 mm. Most of rain falls along the coastal area and it decreases suddenly moving southwards. The humidity in Alexandria is very high; however sea breeze keeps the moisture down to a comfortable level.

c. Land use

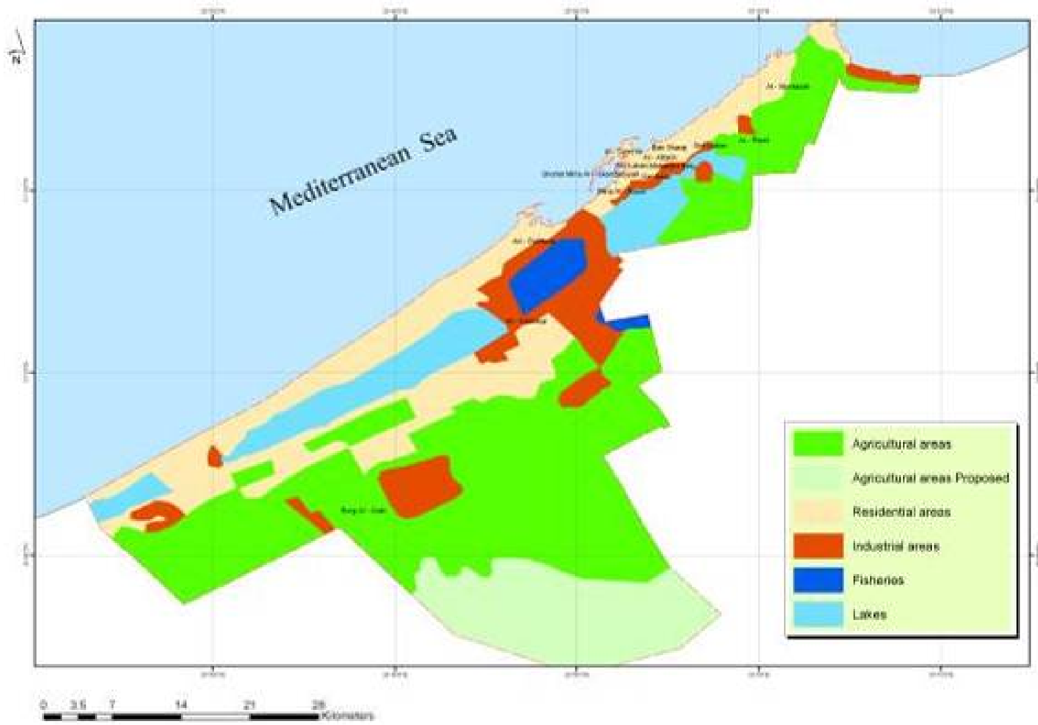
Fig.3 presents the land use map of Alexandria governorate. The total surface area of Alexandria Governorate is about 2680 square kilometer with different land uses which are:

- Desert land which represents about 53% of the governorate area which is about 1430 square kilometers and mainly lies in the west and western south of the city.
- Agricultural uses of total area of about 730 square kilometer represent about 27% of the total area of the governorate which mainly lies in the south and south east. . The cultivated areas are based mainly on Nile water and groundwater is used as a supplementary source in some areas.
- Surface water area which represents about 8% of the total area of the governorate and includes lakes, canals, drains and fishery farms with a total area of about 210 square kilometer.
- Municipality and Urban area which represents the remaining part of the governorate area (about 12% and 310 square kilometer) including the following uses:

    1. Housing buildings of about 46 %

2. Industrial buildings of about 19 %
3. Roads, railway, and marine uses of about 29%
4. Public and recreation areas of about 3%
5. Military buildings of about 3 %

Fig. 3 Land use map of Alexandria governorate.



2. Background to Strategic Planning:

a. The SWITCH Project:

The SWITCH Project (Sustainable Water Management Improves Tomorrow's Cities' Health") is a research partnership funded by the European Commission (EC) undertaking innovation in the area of Integrated Urban Water Management (IUWM). SWITCH is an international consortium of 32 partners from 13 countries, led by UNESCO-IHE Institute for Water Education. The main goal of the SWITCH Project is to develop and implement scientific, technological and socioeconomic solutions that foster sustainable development and integrated urban water management. SWITCH assisted in preparing a strategic planning document in 5 of its demonstration cities around the world. Alexandria City was chosen to represent North Africa and the Arab Region. The project was set for the period between 2006 and 2011.

The **C**entre for **E**nvironment & **D**evelopment for the **A**rab **R**egion & **E**urope (**CEDARE**) is the organization which followed up the activities of the project and made the required coordination between the different related institutions and sectors in Alexandria.

Since the beginning of the SWITCH project in 2006, many activities were achieved , including forming the Learning Alliance group (LA) which consists of a group of representatives from different sectors such as Alexandria Governorate, the Holding company for water and wastewater, Alexandria water company (AWCO), Alexandria wastewater company, CEDARE, Alexandria University, the Alexandria health institution, the Ministry of environmental affairs, and the NGO for Environment , Development, and Culture in Alexandria .

Fifteen LA meeting were held, several workshops and trainings were organized in the field of water demand management, water resources assessment and modeling, visioning and scenario building. In addition the LA has determined a demonstration

site in the City of Alexandria to apply and execute some of the new innovations of the SWITCH Project as a model.

To develop an IUWM strategic plan for Alexandria, ten studies were prepared representing the base for the strategic planning team to develop a strategic plan for Alexandria for the year 2030. These studies covered Water Demand Management, Wastewater Management and Re-use, Urban Water Modeling, Storm Water Management, Ground Water Management, Desalination potential, Nile Water Availability, Financial Sustainability, Social Inclusion and Institutional Mapping.

Available data have been collected for the city water resources covering the historic development of the water system in Alexandria, description and assessment of the current and future Water Demand Management, as well as the activities and responsibilities of different stakeholders including Ministry of Water Resources and Irrigation (MWRI), Alexandria Water Company (AWCO), Alexandria sanitary drainage company (ASDCO), and other institutions involved in water management.

b. The Learning Alliance:

The Learning Alliance was established with representatives from all the Water Sector groups in Alexandria. The Terms of References for these representatives included highlighting the challenges faced in Alexandria with respect to water-related issues, as well as ensuring dissemination of this information between the different LA stakeholders in Alexandria. It was seen to be important to focus on Integrated Urban Water Management (IUWM) and coordinate between the researchers to gather information from all sectors in Alexandria on such matters as resources, infrastructure, stakeholders, and demands of the people. It was also considered important to put in place guidelines for an IUWM plan which had the potential to be developed and implemented in Alexandria and which would substantially address the future water needs of the Governorate. The development of such rules and procedures that governed the functioning of the LA groups needed time and effort to reach widely accepted and clear agreements on the commitments to be made by the SWITCH project partners and the LA Stakeholders. In terms of facilitation of the Learning Alliance, an LA facilitator and co-facilitator were appointed for the city

of Alexandria, as well as several other members of the CEDARE team who provided support in the LA facilitation processes.

Entities Involvement in LA process included:

1. Ministry of Water Resources and Irrigation,
2. Ministry of Housing, Utilities & Urban Development,
3. Ministry of Agriculture and Land Reclamation,
4. Ministry of Health and Population,
5. Egyptian Environmental Affairs Agency,
6. Alexandria Governorate,
7. The Holding Company for Water and Sanitation Services,
8. Holding Company for Drinking Water in Alexandria,
9. Holding Company for Sanitation Services in Alexandria,
10. Professors in Universities and Research Centers,
11. NGOs.

Stakeholders were categorized in two main groups; "Primary" and "Secondary" LA members. Primary stakeholders were the intended beneficiaries of the SWITCH project in Alexandria, whereas Secondary stakeholders were those who were seen to act in the role of intermediaries within the water sector in the Governorate. These two levels assisted in conducting the analysis pertaining to the management of water resources in Alexandria, and the analysis of the stakeholders' involvement in the SWITCH Project.

This was carried out as a series of parallel investigations each one examining the potentials for utilizing other water resources that were both available and feasible to use such as rainwater, groundwater, and desalination in addition to reuse and recycled water resource options.

The principal objective was to reduce dependency on the River Nile water, and to look at integrating one or more of these other potential resources where feasible into the Alexandria raw water supply network. This was being looked at as a central element in the "Integrated Urban Water Management plan" for the city of Alexandria

which was to be the main output for the SWITCH project in Alexandria in an effort to overcome the rapid increase in water demand in the city by the year 2030.

To develop an IUWM Strategic Plan for Alexandria the following steps were carried out:

1. Preparation ten individual studies providing data, testing strategic options in order to feed into the work of the Strategic Planning Team who were developing a Master Plan for Alexandria for Integrated Urban Water Management (IUWM) for the year 2030.
2. Collection of data for the city water resources covering the historic development of the water system in Alexandria, description and assessment of the current and future water demands, the activities, responsibilities and the role played by the different stakeholders in the City, including Ministry of Water Resources and Irrigation (MWRI), Alexandria Water Company (AWCO), Alexandria sanitary drainage company (ASDCO), and other institutions involved in water demand management.
3. Developing a vision for water management in the City of Alexandria in the future taking into consideration the 'city vision' which was formulated previously by the LA in a series of workshops.
4. Reviewing possible scenarios for the future water system in Alexandria City and describing these in quantitative detail. The most promising potential strategies to achieve the overall city vision for water management were determined.
5. Studying the potential for applying these strategies.
6. Evaluating the strategies formulated in to a holistic or integrated plan.

The Current Situation:

a. Water Resources and uses:

At present Alexandria receives an annual average rainfall of less than 200 mm/year and some of the resulting stormwater finds its way into the sewage systems, or drains through stormwater channels into the Mediterranean Sea without use whereas most of the stormwater seeps into the coastal groundwater aquifer through the infiltration areas of the city. Rainfall in Alexandria is clearly limited and its potential likely cost of harvesting these small amounts of water. .

Nile water is the main water supply to Alexandria (and indeed the whole of Egypt) to meet agricultural, industrial, municipal and navigation water demands. Currently, the Governorate of Alexandria is allocated some 12 Million Cubic Meters (MCM)/day of Nile Water as shown in Table.1.

As for groundwater sources, the present total groundwater extraction from within the Alexandria Governorate is only 31Million m3/year this being abstracted from some 1315production wells in total. The Total Dissolved Solids (TDS) ranges between 794 – 3808 ppm.

Regarding desalination, at present there are no desalination plants in Alexandria And it is thought that the future use of such desalinated water resource for different purposes will largely depend on the rate of improvement in the technologies used for desalination and the cost of the necessary power. The current water tariffs make desalination an extremely expensive option for municipal water supplies but certain industrial or leisure uses may well prove to be an entry points for desalinated water in the governorate.

Table 1 shows the water allocations from MWRI to meet all water sectors of Alexandria (Saad, 2010)

Irrigation Directorate	Canal	Served Area in Feddans	Agriculture Demand M^3/day		Industrial Demand M^3/day	Navigation Demand M^3/day	Drinking Demand M^3/day
			Demand at present M^3/day	Actual supply at presents M^3/day			
Nobaria	Nobaria		2927210	1497400	130000	500000	1430000
Al Nasr	Al Nasr	107155	3088650	2316487			
Al Behera	Al Mahmoudia	25000	1000000	1000000	750000		2500000
Summation , M3/day			7015860	4813887	880000	500000	3930000
Present annual demand			12.458 MCM				

Table1. Water allocations to Alexandria (MWRI, 2010)

b. Water Supply :

Alexandria Water Company (AWCO) provides potable water for about 4 million people. This number increases to 6 million in the summer season due to tourist influx from other parts of Egypt. Drinking water service covers more than 95 % of the service area in the city, except for some small parts of the so-called 'slum areas' in which according to the current planning law, the citizens in these areas should submit their building licenses in order to be supplied with drinking water. Because the majority of these dwelling have been built without planning permission the building licenses are generally not available in most cases.

AWCO's drinking water production is maintained through the operation of the existing eight Water Treatment Plants (WTP's) which have a total design capacity of 3.5 million m^3 / day.

AWCO is also responsible for the operation and management of the supply network and distributes the drinking water through its distribution system (34 Booster Pump stations and a total pipeline network of about 8,600 km length) covering the whole served area.

Unaccounted For Water (UFW) reached a comparatively high value of 36% and reducing this value is obviously of great importance when attempting to achieve water savings thereby minimizing the direct impact of leakage/loses on the infrastructure and addressing the excessive cost and low profits that the water company endures. AWCO has already started plans to minimize UFW by implementing District Metering Areas.

Currently AWCO is serving an area along the Mediterranean coast extending from Abu Qir in the Eastern side of the city to El Hammam City located 63 Km west of Alexandria. Also AWCO supplies water to a southern area along the desert highway in Behira Governorate beyond the New Nubaria City, in addition to assisting in supplying Matrouh Governorate with drinking water through five dedicated transmission pipelines. In effect Alexandria sits at the most westerly part of the Nile Water fed system.

AWCO is committed to supply drinking water to the customers with suitable pressure in the network sufficient to reach the third floor of the buildings as is required by the Holding Company. For higher floors in taller buildings customers are required to use pumps to feed reservoirs on the buildings roofs in order to supply water to these dwellings.

Nevertheless AWCO is following a policy aiming at installing a water meter in every household in order to measure (and to reduce the water consumption) accurately in every housing unit and this will also help in estimating UFW across the various DMA's.

Since 2004, AWCO started to apply Supervisory Control And Data Acquisition (SCADA) Systems in the water treatment plants in order to monitor and control the process of water treatment.

The Annual production during the past four years is given in Fig.4, along with water sales volumes. Meanwhile, Fig.5 shows the water consumption by sectors.

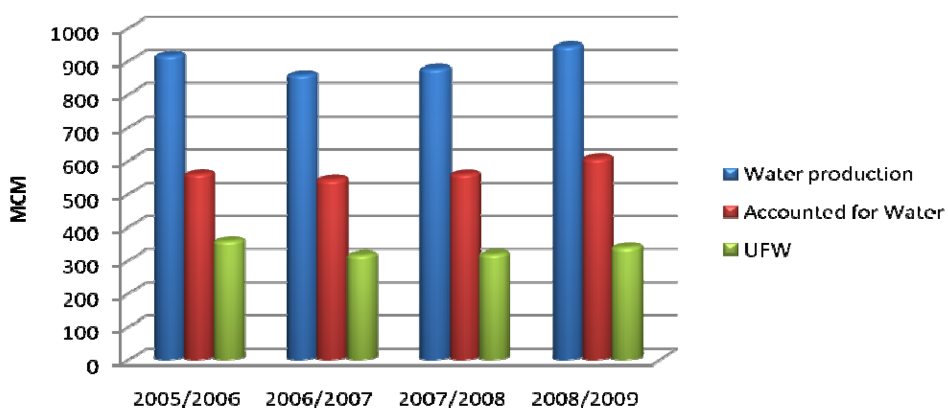


Fig.4 AWCO's annual production

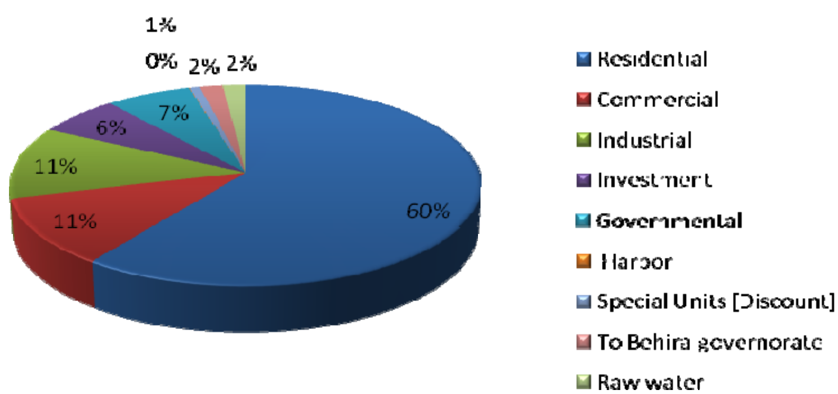


Fig.5 Alexandria's water consumption by sector

Water Tariffs (per cubic meter)

A-Domestic

Tariff/m3

Category 1: from (0-10) m3	0.23 L.E
Category 2: from (11-20) m3	0.23 L.E
Category 3: from (21-30) m3	0.25 L.E
Category 4: more than >30 m3	0.35 L.E

B-Governmental

One category	0.80 L.E

C-Commercial

Category 1:	0.70 LE
Category 2:	0.80 LE

D-Investment – Tourism

One category	1.15 L.E

E-Harbor

Category 1:	12 L.E
Category 2:	24 L.E
Category 3:	28 L.E

Discounted Tariff

Applied for mosques, churches, youth centers, and syndicates

Category 1	0.21 L.E
Category 2	0.42 L.E
Category 3	0.48 L.E

savings as reducing the amount consumed below this 10 m3 does not result in financial savings on the customers bill.

c. Sanitation:

Alexandria Sanitary Drainage Company (ASDCO) is responsible for all sanitation services of Alexandria. Most of the urban areas and about half of the rural area in Alexandria have sewerage systems terminating at a treatment plant. Many rural areas in Alexandria Governorate have no sewerage networks and rely on 'on-site' sanitation. There are also sewerage projects currently under construction in certain of the rural areas and some of the non-served urban areas. The total length of the sewerage systems is about 750 km of various diameters ranging from 200 mm to 2750 mm.

Furthermore, there are two main Waste-water Treatment Plants (WwTP's); the eastern and the western treatment plants respectively. These existing wastewater treatment plants receive the collected wastewater through 80 off-site pumping stations and represent more than 95 % of the wastewater treatment capacity in Alexandria. The existing capacity of the Eastern Wastewater Treatment Plant is about 610,000 cubic meters per day while the capacity of the Western Wastewater Treatment Plant is about 470,000 cubic meters per day. There are in addition a further two treatment plants with smaller capacities which are called, Hanovil Wastewater Treatment Plant -30,000 cubic meters per day and Mubarak Wastewater Treatment Plant of 15,000 cubic meters per day. There are also smaller localized wastewater treatment plants for some rural areas with a total capacity of less than 5,000 cubic meters per day.

Fig.6 below gives the number of population served by water and wastewater facilities as of 1/1/2007.

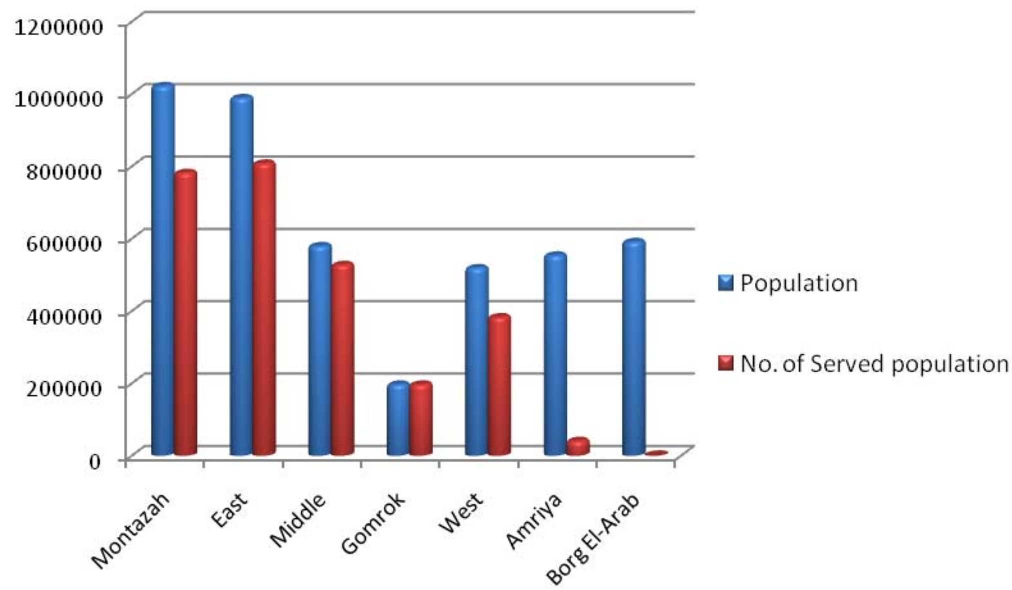


Fig. 6 Served population in Alexandria

Table 2 shows the number of the rural areas in each district of Alexandria and their corresponding population.

District	**Main Village**	**No of Belongs**	**Population**
Montazah	Khorsheed- El-Mohagreen- El-Tabiah - El-kobaniah- El-Emerawy El-Kobra – Mohsen El-Kobra – El-Tawfiqiah – Hood 10	62	203820
Eastern	Abis 2 – Khoseed El-Kebliah	10	21650
Middle	Abis 7 – Abis 8 – Abis 10	26	36334
El-Ameriah	Elmeseery – Deebah – Ahmed Oraby – El-Gazaer	41	151403
Borg El Arab	Bahig – Abo-Seer - Elghrobaniat	N A*	**21805**
Total			**435012**

* N A = Not Available

Table 2 Rural areas and their existing population in Alexandria Governorate

About 50 % of the population of the villages given in table.2 has no sewerage system and depend entirely on these 'on-site' sanitation or similar systems for the provision of some degree of treatment before discharging to local agricultural drains... However, many of these rural areas have projects currently defined for executing sewerage systems ending with treatment plant.

Generally in rural areas where there is no sewerage network, the raw sewage has on-site treatment (septic tanks) or is disposed into the nearest agricultural drain or surface water body. Every household has in effect has to act on its own and provide

some form of sanitation; unsealed latrine pits and cesspools facilities are rarely adopted. They depend on disposing their sewage using leaching pits situated adjacent to their houses or on direct discharge of raw sewage to drains using vacuum trucks.

The new projects include for the provision by ASDCO of treatment plants and sewerage systems to these areas. The new wastewater treatment plants include six plants in addition to the extension of the Eastern and Western treatment plans. The new treatment plants projects will add a further capacity of about 500,000 cubic meters per day to the existing capacities. Table.3 shows the new, planned wastewater treatment plant projects. Some of these projects have almost been completed and are undergoing testing and are expected to be in service very soon.

No.	Name	Capacity m3/day	Area Served	Remarks
1	Hanouvil 2 Plant	30,000	El-Dekheelah – El-Max – Om Zeghboo Rd. – Part of El-Agamy	mostly completed
2	El-Zawaidah Plant	15,000	Villages of Khoursheed – El-zawaidah – El-Tawfiqiah – Shaker -	
3	El-Syouf West Plant	10,000	Villages of El-Syouf West – El-Bakatoush – Galal Ibrahim	
4	El-Mallahah Plant	10,000	Villages of West El-Mallahah – Masood- El-Brins – Serkis – el-Tarouti	
5	El-Agamy Plant	145,000	Bitash – El-Agamy - El-Agamy Beach	
6	Old El-Aameriah Plant	50,000	Old El-Aameriah – Merghem-Abdel-Kader Villages	
7	Extension of Eastern Plant	200,000		
8	Extension of Western Plant	100,000		

Table 3 Wastewater treatment plant projects under construction.

There are also several sewerage projects currently under construction in rural areas and some of the non-served urban areas. After completion of these projects about 80% of the presently un-served rural areas will have sewerage systems for collection of wastewater and final pumping to appropriate treatments plants before disposal to the nearby drainage channels.

3. Future threats and uncertainties:

a. Nile Water Availability:

The available Nile Water for Alexandria Governorate reaches it through three main canals which are:

- Nobaria canal
- El Nasr canal
- El Mahmoudia canal.

These canals supply Nile Water to the Governorate which is required to meet agricultureal industrial, municipal and also navigation water demands.

A study was performed to check if there were any future plans to increase Alexandria's allocation of Egypt's Nile Water through canal expansion programs. The previously expected findings of this study ensured the need for finding alternative water resources by 2030. The study showed that there are some limited canal expansion plans that would only affect their conveyance in terms of restoring these back their original design discharge. This will not significantly enhance the Nile Water availability in Alexandria.

b. Climate Change:

According to the Intergovernmental Panel on Climate Change (IPCC) third assessment report, Alexandria is among the most vulnerable cities to sea level rise and has a very limited capacity in terms of undertaking any of the three common strategies which are: adapt, retreat, or defend. A scenario involving a sea level rise between 0.5 and 1 meter over the current century may lead to an inundation of about 30% of the governorate if no proper action is taken. (IPCC, 2001).

The IPCC fourth assessment report has now pointed out that temperature increases have been observed in Alexandria from 1979 to 2005; however, the report did not

record a change in precipitation during the same period due apparently to insufficiency in data. (IPCC, 2007).

In order to try and throw more light on this phenomenon CEDARE has performed a detailed climatic analysis using temperature and precipitation data from 1957 to 2009. The results, however, appear to show no particular evidence of a fixed trend as is illustrated in section 6. b.

c. Population:

The results of the last census for Alexandria population are given in table.4. The average rate of increase in the whole governorate was 1.36 %. The population increases in summer is by some 35%.

District	Population	Rate of increase	Total area (feddan)	Building area (feddan*)	Density (Capita/ feddan)
Montazah	1,217,535	1.37	19300	8697	116
Eastern	1,003,965	1.26	11600	1697	578
Middle	613,925	0.94	8300	1711	337
Customs	196,402	1.17	642	642	305
Western	514,506	1.54	7100	1849	278
El-Ameriah	697,450	2.23	515700	56558	9
Borg El Arab	81,977	2.77	75100	2238	25
Total	4,325,760		**637742**	**73392**	

*Note Feddan = 4200 m^2.

Table 4 the last Census population (2006) and its distribution in Alexandria

As for the future Alexandria population, tables.5 and 6 give the estimated population given by the Master Plan 2030 carried out for the Alexandria Water Company.

Service Area	Estimates of number of inhabitants by year, (in thousands)						
	2006	2012	2017	2022	2027	2032	2037
Alexandria	5,110	5,608	6,089	6,548	7,073	7,637	8,246
North Coast	338	408	478	560	447	768	899
Beheira	132	154	175	199	226	257	292
Total	**5,580**	**6,170**	**6,742**	**7,307**	**7,746**	**8,662**	**9,437**

Table 5 Estimated Populations in the Service Area in the Future Years

Service Area	Estimates of number of inhabitants by year, (in thousands)						
	2006	2012	2017	2022	2027	2032	2037
Alexandria	3,885	4,262	4,605	4,973	5,371	5,800	6,264
North Coast	218	263	308	361	423	495	579
Beheira	132	154	175	199	226	257	292
Total	**4,235**	**4,679**	**5,088**	**5,533**	**6,020**	**6,552**	**7,135**

Table 6 Estimated Populations in the Service Area (Peak Summer Period)

The inhabited area of the Governorate covers an area of about 307 km^2, representing about 11% of the total area of the Governorate itself.. The total population of Alexandria in 2006 was about 4.11 million people, giving an average population density of about 11,132 persons/km^2. The spatial variations in population density between different districts are quite evident with the central old section of the city; the Wassat district having an average of 133,460 persons/km^2.

The Governorate has been experiencing rapid rates of population increase over the past three decades. For instance, the total population reached in 2006 was about 4.110 million people compared with 3.339, 2.927 and 2.318 millions in 1996, 1986 and 1976, respectively as shown in fig. 7 below.

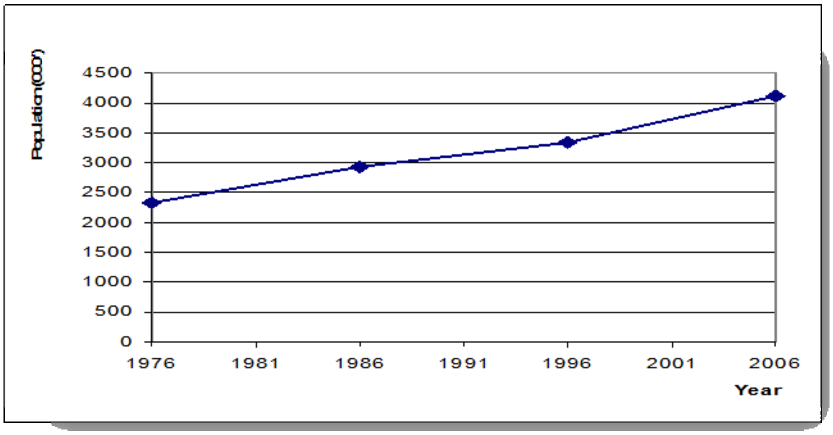


Fig. 7 Population of Alexandria from 1976 to 2006

This means an absolute increase of about 1.972 millions, or 77%, over the past three decades. The spatial distribution of the population was found to be rather uneven between different the districts of Alexandria, with the inner district, Wassat, reaching its saturation level. This may reflect the need for a future expansion of the city in to currently uninhibited areas of Alexandria which maybe much further away from Nile Waters but possibly closer to groundwater or even seawater resources. Figure 8 shows the future increase in production that AWCO needs to service in the future.

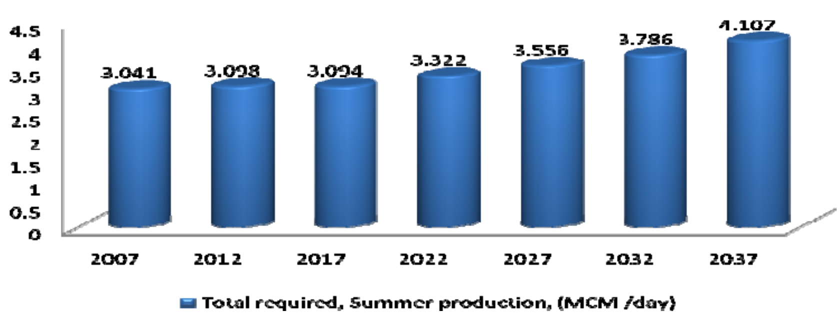


Fig.8 AWCO's future required summer production

4. The 2030 Alexandria Water Vision

A vision was developed for water resources management in the City of Alexandria in the future taking into consideration the City Vision that was formulated previously by the LA stakeholders. This vision expresses the hopes in achieving a sustainable urban water supply system by the year 2030. Possible scenarios for the future water system in Alexandria City have been described. The potential strategies to achieve the vision for water demand management have been determined.

The vision states:

'*We envisage a city where available water resources are managed in an integrated manner, with the participation of all citizens, and are used effectively for development within a framework of environmental sustainability, where all citizens have access to high quality (according to national norms), reliable, sustainable, and affordable water and sanitation services and benefit from a clean and healthy environment.*'

The LA also identified three possible future scenarios for the year 2037 which was initially intended to be the target year for strategic planning. The scenarios are as follows:

a. Worst case scenario (pessimistic)

"In 2037, Alexandria is a city characterized by continued explosive population growth (summer population 12 million), a weak and stagnant economy, low availability of Nile water which is 40% less than in 2007 (due to poor international cooperation and climate change), increased risk of flooding (due to sea level rise), and poor availability of financial resources".*

b. Best case scenario (Optimistic)

"In 2037, Alexandria is a city whose population has largely stabilized (at million), is benefiting from a dynamic and fast growing economy, has a guaranteed share of Nile water similar to that of 2007, and where climate change has tended to the most positive of scenarios (with sea level rise minimum, and increased rainfall). The new vitality of the Egyptian economy means that financial resources are readily available".*

c. Business as usual (Realistic)

"In 2037, Alexandria continues to be city dealing with considerable uncertainty. Population is 10 million, and continues to grow. Share of Nile water is 20% less than in 2007, while economic growth has been steady but unspectacular. Rising sea levels are starting to threaten some parts of the city".*

Note*. The initial LA Visioning Workshop included for the planning horizon of 2037 in order to match the then, current, Alexandria Master Plan.

5. IUWM Strategies to meet Future Water Demand:

a. Groundwater Potential:

One of the clear objectives of the Alexandria Strategic Planning process was to assess the groundwater potential in the Alexandria Governorate in order to see the potential for increasing its contribution in the overall water resources policy of the Governorate.

A well inventory for all production wells in the Alexandria Governorate was carried out during the period June – August 2009. The results of this study indicate that the existing production wells are distributed all across the 9 areas as shown in fig.9. These are in summary:

- Total number of production wells is some 1315 in all.
- The normal drilled depth of these wells varies between 6-45 m.
- The depth to groundwater ranges between 1.5 -18 m.
- The rate of groundwater abstraction for each well varies from 2-60 m3/hour.

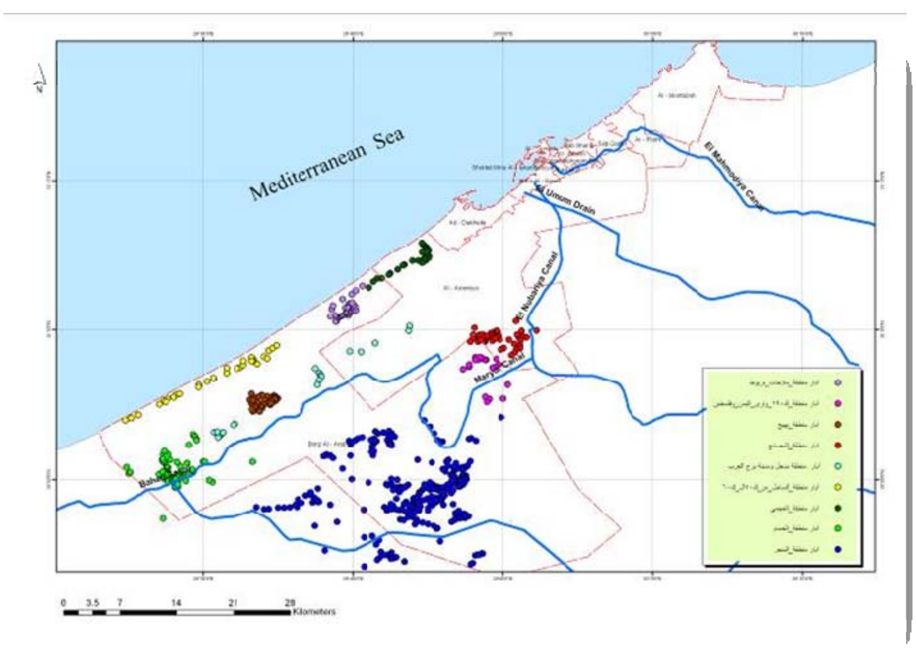


Fig. 9 Location of the production wells in Alexandria Governorate.

The present total quantity of groundwater abstracted in the Alexandria Governorate is around 31 MCM/year and is mainly used for agriculture. The number of active production wells and related abstraction points were distributed among the existing aquifers as presented in table.7 below.

No.	Aquifer	No. of Wells	Present Extraction m^3/year
1	**Coastal Aquifer**	373	1,573,590
2	**Nile Delta Aquifer**	190	2,702,830
3	**Ralat aquifer**	752	26,808,830
	Total	**1315**	**31,085,250**

Table.7 Groundwater Abstraction (m3/year).

It was, therefore, concluded that ground water could contribute some additional 33 MCM annually to the overall Water Resources Budget for Alexandria.

b. Storm Water Potential:

There are six rainfall stations in Alexandria.

Rainfall data for Nozha Station for the period from 1957 to 2009 were obtained. The data covers series for daily, monthly and annual rainfall.

The analysis of annual rainfall for Nozha station reveals that the average annual value for the available data is 169 mm. Fig.10 below shows a plot of the annual rainfall for the available data from 1957 till 2009. Another weather station at Alexandria Port shows that the average annual rainfall for the period from 1868 and 1973 is 197.4 mm.

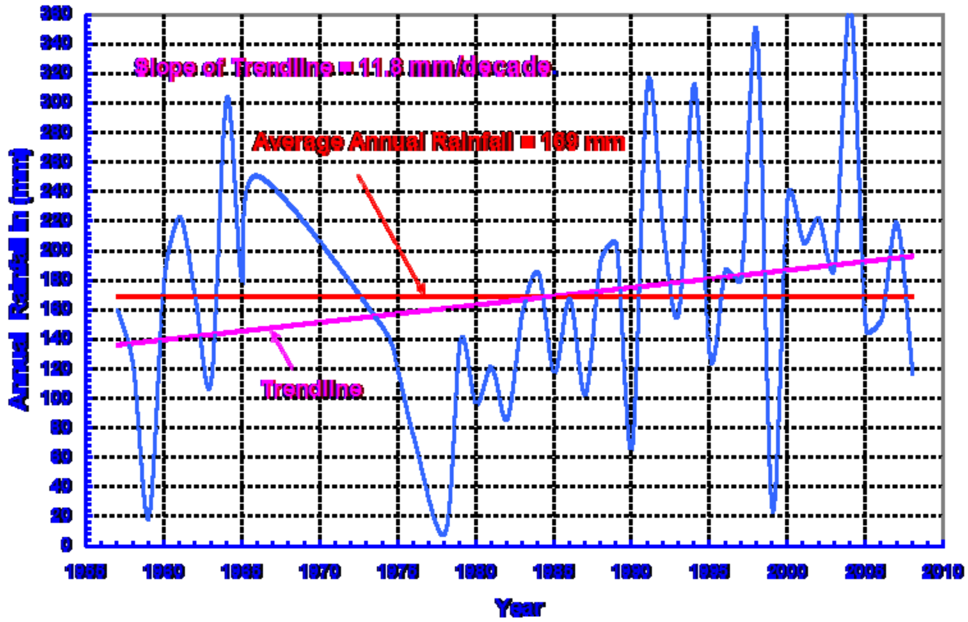


Fig. 10 Annual Rainfall for Alexandria - from 1957 – 2009.

To examine the potential for rainfall to positively contribute towards the Alexandria Water Resources Budget, these daily rainfall series were studied. The average monthly rainfall for the 'rainy months' was, therefore, considered and months which gave similar average monthly rainfalls were been identified.

It became clear that rainfall in Alexandria is very limited and its potential, therefore, to provide such a positive contribution to the overall water budget is low and not promising in order to promote the use of cost effective, sophisticated Best Management Practices (BMP's); such as rainwater harvesting, porous pavements and infiltration devices. However, it may never the less be useful to apply some simple BMPs which could help to alleviate the sometime heavy, short duration winter rains that can lead sometimes to localized urban flooding. These would need to be identified in a separate initiative.

c. Water Demand Management Potential:

The main purpose of the various Demand Management options was considered by the DM Study Team according to the different future scenarios above. These options were considered in terms of potential amounts of water saved and the relevant cost savings derived.

Three important strategic options that are likely to make significant contributions to the amount of water that could become available by 2030* were suggested.

The first strategic option involved minimizing physical and commercial losses from pipe distribution network; it was demonstrated that some 20 MCM could be made available annually by applying this strategic option.

The second strategic option was to look at increasing the drinking water tariff, gradually in a manner that could save potentially 60 MCM annually commencing from 2030; this amount equatess to the value of monetary savings resulting from an average tariff increase of 5%.

The third strategic option focused on maximizing household water use and promoting water efficiency and it was estimated to potentially result in savings of some 44 MCM annually.

Note*: The new Alexandria Master Plan Horizon.

d. Waste Water Reuse Potential:

At present the wastewater treatment plants provide only Primary treatment and treated water is conveyed to Lake Maryut form where it is pumped for final disposal to the Mediterranean Sea.

Strategic options for wastewater management and reuse in Alexandria were formulated with the objective of achieving Sustainable Integrated Urban Water Management system in Alexandria by the year 2030. These strategic options took into account a number of different scenarios, in terms of population growth, wastewater flows, wastewater composition, expansion of the sewer system, demand for treated effluent in industry, urban landscaping and agricultural uses, climate change, salt water

intrusion/sea level changes, regulations and effluent standards to be achieved. It was shown that if treated wastewater was used to satisfy the above demands it could potentially contribute about 900 MCM yearly to the overall water budget for the Governorate and in particular for use in agriculture in order to supplement the irrigation water currently provided far as part of the Nile water allocation. Fig.11 shows the two most favored** options in reusing treated wastewater in agriculture, which are the proposed Hammam agricultural site and the so-called ASDCO irrigation site.

Note ** these sites being selected by discussion with the Ministry for Water Resources and Irrigation, ASDCO and the Master Planning Department

Fig 11 a - Options for using treated wastewater in Agriculture at Hammama.

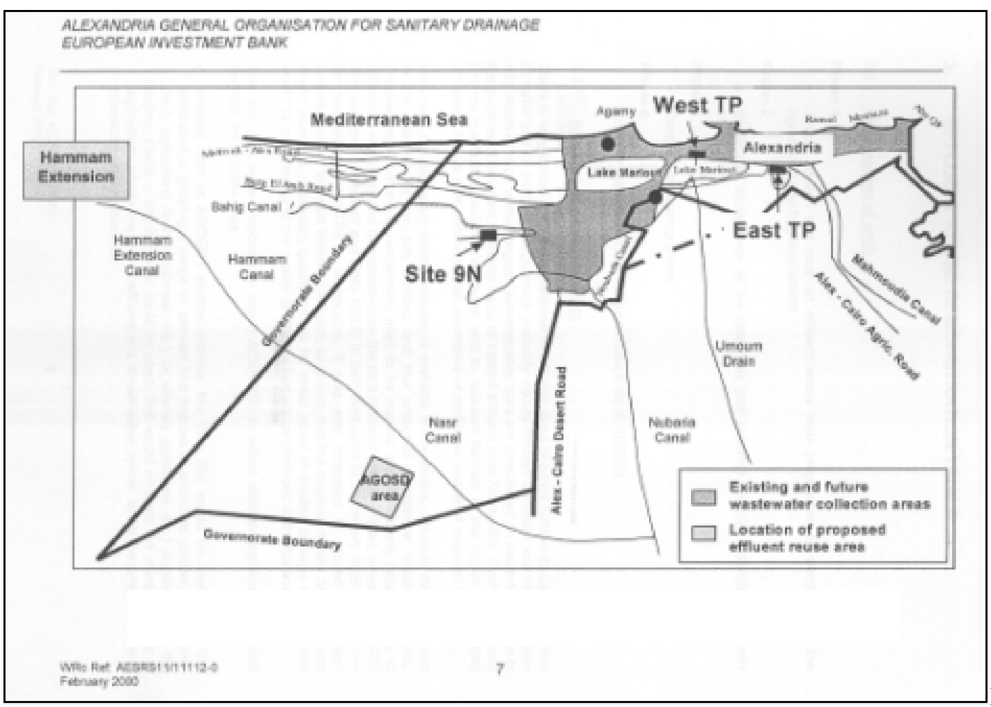


Fig.11

Fig 11 b - Options for using treated wastewater in Agriculture (ASDCO)

e. Agricultural Drainage Reuse Potential

In this strategic option (Fig. 12), brackish, agricultural drainage water would be extracted from the major agricultural drains and be treated in an appropriately designed desalination plant so that it is suitable for use in industrial facilities and as a non-potable supply source for use in coastal resorts as well as potentially in agriculture. The concept for this option is illustrated in Fig.12 below where the red dot marks the proposed potential location of a desalination plant and the red lines represent the routes of major trunk mains for the supply network.

For this option, it has been assumed that the treated water would be delivered in a separate network and used essentially as a non-potable supply source. However, the resulting water is likely to be of a very high quality following pre-treatment and desalination, so it is possible that this water could be added to the existing water supplies (Nile Water) in the Noubariya canal. However this particular potential sub-option would need to be examined and determined by the Water Resources and Irrigation Authorities. The 'brine' and any back-wash water resulting from this treatment process would require careful consideration as to the selected method of its disposal.

In this study it has been assumed that a separate pipeline would be used to discharge the brine into the sea, however, the impacts of this would need to be studied more carefully to ensure there will be no adverse impacts on the local coastal environment as a result (White, et al, 2011).

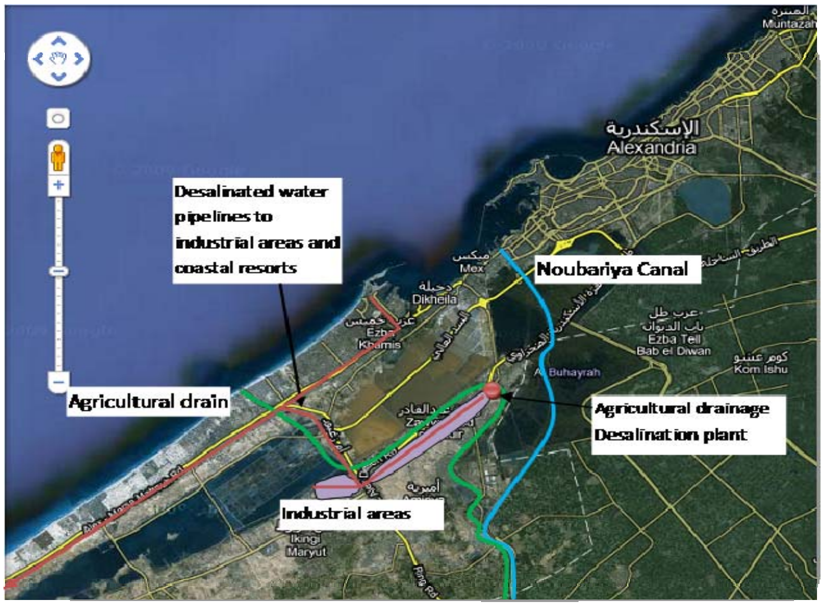


Fig.12 Agricultural Drainage Reuse Option (White, et al, 2011)

f. Sea Water Desalination Potential:

Desalination plants operate in approximately 125 countries, with seawater desalination plants contributing 59 percent of the total worldwide desalination capacity. For Alexandria, it has been concluded that seawater desalination, as a conventional water resource would most probably only be considered as a measure aimed at essential water security. The future use of such resource technology in the Governorate for other more common demands will largely depend on the rate of improvement in the technologies used for desalination and the costs associated with these processes, such as energy and membranes, etc. (White. et al, 2011). At present there it is understood that there are no planned, large scale, desalination plants in Alexandria.

A critical issue in water desalination is the high energy demand and, more specifically, electricity for Reverse Osmosis (RO) desalination units. However, it has nevertheless been shown that RO is the preferred desalination process (with the lowest overall energy requirement) and therefore, it was anticipated that significant efforts would be taken to further develop what is currently quite widely available and

environmentally compatible energy sources for the purposes of water desalination facilities in the Governorate.

It has also been demonstrated that if sufficient funds were made available, the maximum amount of desalinated water could potentially reach up to some 777 MCM annually starting from 2030, and this is estimated based on the needs of some particular coastal areas where future development and expansions are anticipated. This would also have the potential effect of reducing the demand on the current AWCO supply system to governorates lying to the west of the city. The most suitable locations considered in this study for such desalinated water would be used have also been determined. Moreover, a desalinated water system that could produce up to 2.13 MCM of desalinated water daily has been proposed, with between 5 – 6 1020 MCM/annum facilities of would be required to produce the above mentioned daily amount. Fig. 13, below shows the location of such a potential desalination plant.

Fig.13 Location of a potential desalination plant (White et.al, 2011)

g. Urban water reuse:

One of the most important objectives of Strategic Planning Study was promoting the concept of planned urban water management through computer based modeling which would allow a common practice collaborative platform between the planners and the water companies now and in the future in Alexandria.

Hence, some strategic options were assessed using the computer based "AQUACYCLE" modeling software.

Although merely being able to establish a basic numerical urban water model to the different districts of Alexandria would have been a great success in itself, the application of the model to the assessment of three strategic alternatives re-use, those of 'grey' water, roof run-of water and road surface water run-off reuse, the model has showed that these options, or combinations of them, could potentially introduce some 23, 14 or 25 MCM annually to the overall Alexandria water budget respectively.

h. Analysis of strategic options:

The next step in the process was to investigate all strategic options collectively and to test which of them appear to lend themselves to being combined into Integrated Strategic Options and to explore the practicality and feasibility of providing the theoretical additional amounts of water resources indicated for every strategic option.

It is worth mentioning that currently all of Alexandria's water is produced through the Alexandria Water Company's treatment facilities which means in effect that all sectors (Industrial, irrigation, domestic, etc.) receive the same quality of water, which is the quality required for potable consumption. This is certainly something that needs to be addressed in the future where the provision of variable qualities of water may be more appropriate.

It should be recognized that the different potential saving/additional amounts that were estimated for every strategic option cannot be necessarily added altogether to produce an overall potential resource as some of the options are mutually exclusive. However it is reasonable to assume that the amount of available water to the city of Alexandria in 2030 could exceed the actual extrapolated demand needs if the strategies suggested in this study are substantially adopted. This basically means that the current Nile Water resources combined with the 'additional potential resources' identified in this study could be sufficient to satisfy the projected demand at the 2030 planning horizon.

The storm water management options were examined by the urban water modeling package AQUACYCLE have in effect been eliminated from further assessment due to the low potential and high costs of recovering rainwater from utilizing these options. Similarly with grey-water reuse, the likely costs of widespread retrofitting grey-water collection, treatment and distribution would be very high relative to the low cost of raw (Nile) water in the country. Whereas it was accepted that in certain new developments introduction of grey-water recycling (for landscape irrigation, etc.) that more expansive systems would not be cost effective or manageable in the normal urban context.

Groundwater promises to be a main option for Alexandria in the future given the fact that such water resources relatively close to the potential demands.

Desalination is yet another promising future resource for Alexandria, given its location adjacent to the Mediterranean Sea and Lake Maryut although it was considered that based upon costs then desalination would provide specific localized demand options such as industry and tourism.

The Water Demand Management options are all currently within the planning process of AWCO and the first option of minimizing physical and commercial losses has been included in accordance with an actual plan made by the AWCO to implement DMA's throughout their networks over the next ten years starting from 2011, which aims towards saving some 198 MCM in 10 years.

Other Water Demand Management options that were proposed in a joint research effort between CEDARE and The Institute of Sustainable Futures at the Technical University of Sydney (ISF-UTS) are considered in the overall assessment later in this report owing to their high level of feasibility and practicality of application within the Alexandrian context.

Arguably the strategic options that provide the next level of 'fit' are those that involve the use of treated wastewater in agriculture and in particular to the locations identified in and highlighted in Table 9, which are referred to as Hammam Extension and the ASDCO Site as show in Fig.11a & b respectively.

It should be noted that the two major wastewater treatment plants are also shown in the same figures (referred to as East TP and West TP) and that both of these options for re-use of final effluent vulnerable as the current laws stand in Egypt. Law 48-1982 specifically forbids the discharge of treated waste water into irrigation canals and hence, regardless of the technical feasibility of both options, the actual implementation of these would require some very fundamental changes in the current institutional arrangement in Alexandria and indeed to Egypt.

When examining the Agricultural Drainage Water reuse option is also considered to be a very important and available strategic option as the amount entering Alexandria

reaches some 7.5 MCM daily and studies are currently in progress to assess the possible future reliability of that particular resource and the costs and efficiency of treatment methods associated with this.

In order to commence the process of an overall or combined options assessment, Fig. 14 shows an overall layout of Alexandria that reflects the current situation with respect to the total potential water budgets and current demands. The current total annual demand is 3,492 MCM and it is recognized that a significant proportion of this amount is not used effectively, especially for example in agricultural drainage water as well as the large amounts of irrigation water lost at both the national and farm levels.

It can be seen from Fig 8 that the estimated Water Demand in 2030 is 3.671 MCM daily, which corresponds to 1,339 MCM annually and this has been set as the target amount required in order to satisfy the overall expected demand using the previously discussed strategic options or combinations of these.

Similarly, it can be seen from Table. 6, that the estimated population of the Governorate at 2030 horizon is expected to be some 6.28 Million. Table 8 shows that the recorded demand in 2010, when compared to the projected demand of the year 2030, under the exact same general constraints as in 2010 (i.e. known as the 'business as usual' model) would give an annual demand of some 1,322 MCM.

CURRENT SITUATION			2030		
Year 2010			Buisness As Usual		
Total Water Produced		947343750	1505		
Total Water Sold		606300000	963		
Population		4670000	6285000		
Category	Consumption		Consumption		Volume
	%	L/C/D	%	L/C/D	m.m3/year
Domestic	61.16	218	61.16	218	589
Industrial	11.2	40	11.2	40	108
Commercial	11.71	42	11.71	42	113
Investment	6.51	23	6.51	23	63
Govermental	6.73	24	6.73	24	65
Harbour	0.03	0	0.03	0.1	0
Discounted Units	0.86	3	0.86	3	8.4
Exported (Behira)	1.8	6	1.8	6	17
Sum W/O losses	100	356	100	356	963
UFW , %	36		36		
UFW		200		200.08	542
Sum ALL INCL UFW		556		556	1322

Table 8 Current and future water demand

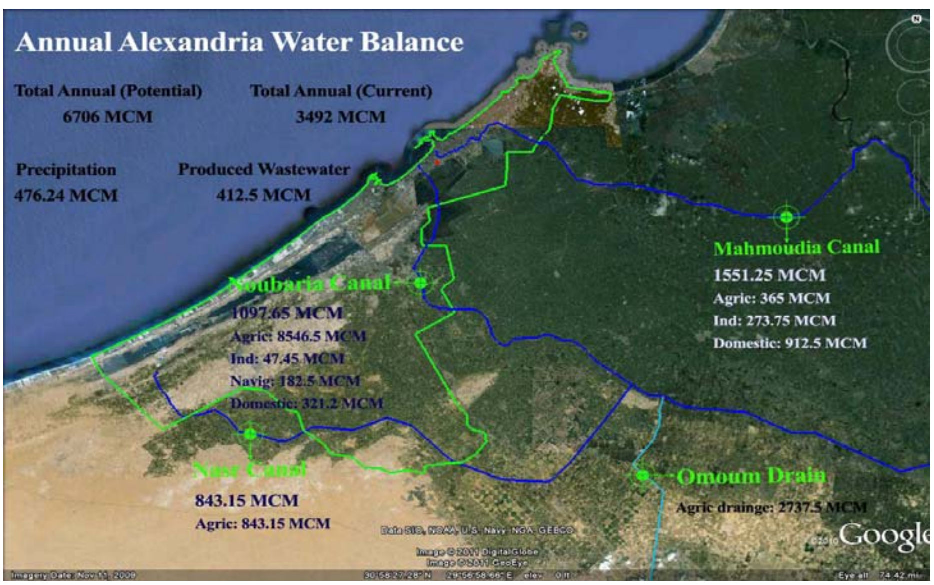


Fig. 14 Alexandria Overall Water Budget

6. Meeting Multiple Objectives & Strategy Ranking

The institute of Sustainable Futures at the Technical University of Sydney (ISF-UTS) and CEDARE have modeled different supply and demand options reflecting all of the above Strategic Options. The results from this modeling exercise gives the relevant water savings and associated costs of each option and these are shown in Table. 9.

The Demand Management options tended to be the most cost-effective with options DM7 and DM8 standing out for their cost-effectiveness and high potential in terms of water savings. Unsurprisingly seawater desalination was found to be the least cost-effective of the 16 options modeled as at US$ 1.15 /m3 it almost double the second most expensive option, which was agricultural drainage desalination at US$ 0.63 /m3.

Figure 15 shows the contribution of each of these strategic options towards fulfilling the 2030 Water Demand whilst Figure 16 shows the final ranking of all strategic options considered in a way that reflects the suggested order of strategic implementation. Total water savings of some 603 MCM/year are therefore projected for 2030.

Table 9 – Water Savings and Associated Costs.

Code	Options	Present Value(million $)	Water saved or supplied in 2030 (Mm3/a)	Unit cost (PV$/PVm3)
DM1	Water saving fittings retrofit	21.4	26	0.08
DM2	Toilet replacement program	32.5	6	0.53
DM3	Tourist & commercial audit & retrofit	32.2	30	0.11
DM4	Government buildings audit & retrofit	33.2	41	0.08
DM5	Industrial customers efficiency improvement	21.4	34	0.06
DM6	System leakage reduction	9.6	59	0.02
DM7	Tariff reform	0.3	57	0.00
DM8	Agricultural efficiency offsets	5.9	75	0.01
DM9	Appliance efficiency regulation	1.4	21	0.02
S1	Seawater Desalination	408.9	42	1.15
S2	ETP and WTP wastewater reuse for industry	163.1	32	0.60
S3	Agriculture drainage desalination & reuse	334.2	62	0.63
S4	ETP and WTP wastewater reuse for agriculture	254.6	63	0.48
S5	Groundwater for green space irrigation	68.5	18	0.48
S6	Local wastewater reuse for new developments	56.9	37	0.40

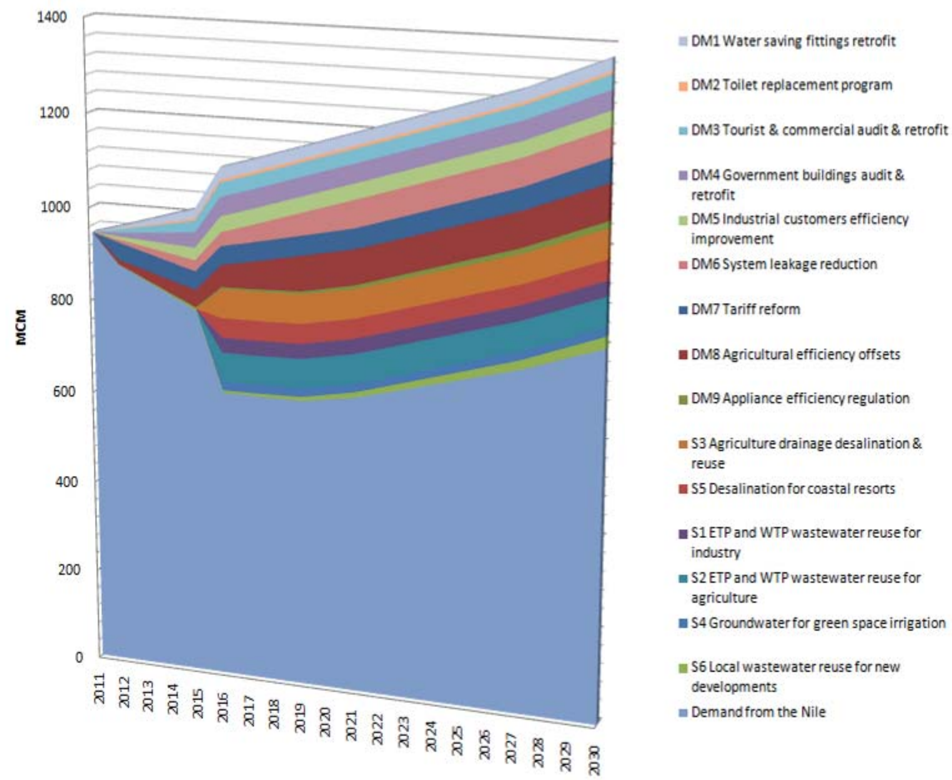


Fig 15: Projected Water Demand in Alexandria to 2030

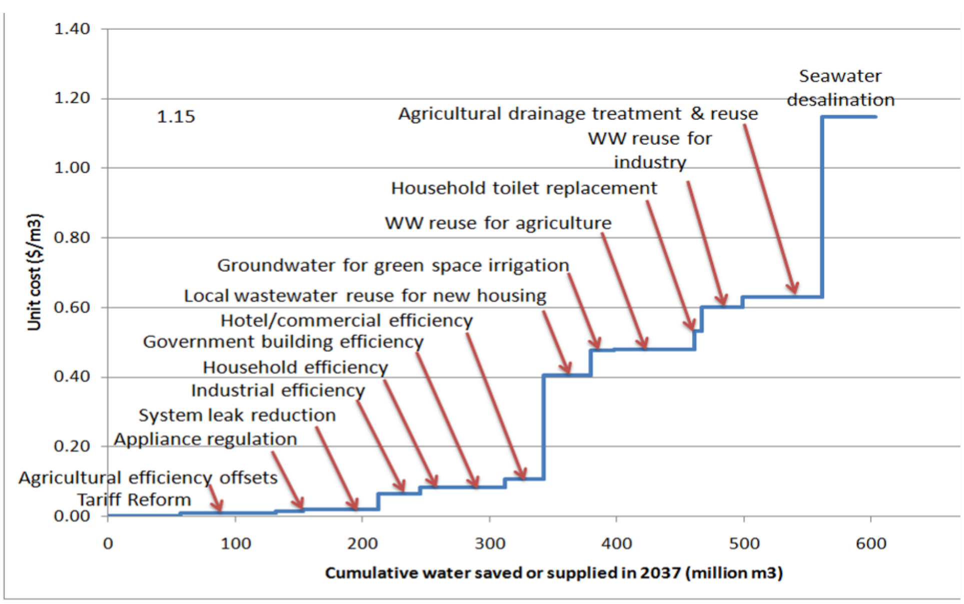


Fig 16 Supply curve for all Strategic Options considered

On the assumption that the uptake of both Sea Water Desalination and Agricultural Drainage treatment and reuse will increase in the near future and the regulatory problems associated with the reuse of waste water will be resolved, some 603 MCM/annum of raw water could potentially be saved. This would significantly relieve the pressure on the demand for Nile Water, which is currently between 900-1400 MCM annually.

With this level of potential raw water saving at the 2030 planning horizon then with from non-surface water options, theoretically only 736 MCM would in fact need to be allocated from the Nile River to Alexandria, which if implemented would be an outstanding success for the Governorate.

Table 9, below shows the potential final water allocations and the total associated costs for each of the options selected for Alexandria in 2030. It is clear that the total anticipated annual cost needed to implement all these options in the table amounts to around some 200 Million US$ at current rates, which is probably unaffordable at this point in time. However, this amount, although large is probably much more affordable when compared to the likely cost of, for example, providing the same volume of 'new water' (603 MCM) by desalination only when the equivalent cost would be in the region of some 700 Million US$.

It is also worth noting that this Strategic Plan, if appropriately adopted and implemented, would contribute greatly to the national effort to reduce Egypt's reliance on Nile Water and to adopt sustainable water management practices which will also benefit other cities/ governorates by acting as an exemplar of good management practice.

The potential amounts of water that could be saved from the Nile Water allocation ranges from 164 to 664 MCM, depending upon which option or combination of options are adopted, could be also be redirected to other inland governorates with no desalination potential and lying outside any significant ground water zones.

Code	Options	Water saved or supplied in 2030 (Mm3/a)	Unit cost (PV$/PVm3)	Total Cost (US$)
DM1	Water saving fittings retrofit	26	0.8	20800000
DM2	Toilet replacement program	6	0.53	3180000
DM3	Tourist & commercial audit & retrofit	30	0.11	3300000
DM4	Government buildings audit & retrofit	41	0.08	3280000
DM5	Industrial customers efficiency improvement	34	0.06	2040000
DM6	System leakage reduction	59	0.02	1180000
DM7	Tariff reform	57	0	0
DM8	Agricultural efficiency offsets	75	0.01	750000
DM9	Appliance efficiency regulation	21	0.02	420000
S1	Seawater Desalination	42	1.15	48300000
S2	ETP and WTP wastewater reuse for industry	32	0.6	19200000
S3	Agriculture drainage desalination & reuse	62	0.63	39060000
S4	ETP and WTP wastewater reuse for agriculture	63	0.48	30240000
S5	Groundwater for green space irrigation	18	0.48	8640000
S6	Local wastewater reuse for new developments	37	0.4	14800000
Total		603		**195,190,000**

Table 9 Water Volumes and Costs for 2030

7. Sustainable IUWM Indicators:

It has been proposed that different indicators will be used in order to assess the relative strengths and weaknesses of each Strategic Option considered.

The purpose of this assessment is to provide indicative numerical values for use by the specific governmental entities that would be expected to implement this plan. All of the options would be evaluated on a scale of 1 to 5, where a negative sign will indicate either a negative effect or expenditure where appropriate. Hence for example zero would indicate a neutral effect of an option with respect to a particular indicator. In this particular instance these indicator scores have been assembled by one sustainability expert in the team whereas it is expected that in practice the implementing authorities would take the views of a much larger body of key experts in order to best establish appropriate indicators based on the situation 'on the ground' at the time. This could be achieved by using a participatory workshop or other similar exercise in the future.

a. Economic Indicators:

I. GDP and economic return:

Strategy	Impact
Increase in tariff (5% per year for 5 years)	2
Minimization of physical and commercial losses from distribution network	2
Improving household water use efficiency (a reduction of 25% realized over a 5 year period)	2
Reuse of treated wastewater in urban green areas	0
Agricultural reuse of treated wastewater at ASDCO site (new agriculture)	2
Reuse of treated wastewater in green areas along highways and in the cities green belt	0
Grey Water Reuse for irrigation	-1
Agricultural reuse of treated wastewater at Hamam site (new agriculture)	3
Irrigation of urban green areas with groundwater	-2
Artificial recharge	-3
Brackish water desalination	-2
Sea water desalination	1
Rainwater harvesting for irrigation of urban green	-2
Agricultural reuse of treated wastewater within the governorate (existing agriculture, SWAP)	3
Agricultural Drainage Reuse	3

The above table shows that some options have a relatively high economic return especially those that involve re-use of either treated waste water or agricultural drainage water.

II. Cost per unit volume:

Strategy	Impact
Increase in tariff (5% per year for 5 years)	5
Minimization of physical and commercial losses from distribution network	-1
Improving household water use efficiency (a reduction of 25% realized over a 5 year period)	-1
Reuse of treated wastewater in urban green areas	-2
Agricultural reuse of treated wastewater at ASDCO site (new agriculture)	-2
Reuse of treated wastewater in green areas along highways and in the cities green belt	-2
Grey Water Reuse for irrigation	-2
Agricultural reuse of treated wastewater at Hamam site (new agriculture)	-4
Irrigation of urban green areas with groundwater	-3
Artificial recharge	-4
Brackish water desalination	-3
Sea water desalination	-4
Rainwater harvesting for irrigation of urban green	-3
Agricultural reuse of treated wastewater within the governorate (existing agriculture, SWAP)	-2
Agricultural Drainage Reuse	-4

From the table above, it is shown that the "Increase in tariff" strategy has the lowest cost per unit volume as it will not trigger any significant capital investments.

b. Social Inclusion Indicators:

I. Affordability:

Strategy	Impact
Increase in tariff (5% per year for 5 years)	-1
Minimization of physical and commercial losses from distribution network	-1
Improving household water use efficiency (a reduction of 25% realized over a 5 year period)	1
Reuse of treated wastewater in urban green areas	1
Agricultural reuse of treated wastewater at ASDCO site (new agriculture)	1
Reuse of treated wastewater in green areas along highways and in the cities green belt	1
Grey Water Reuse for irrigation	1
Agricultural reuse of treated wastewater at Hamam site (new agriculture)	1
Irrigation of urban green areas with groundwater	1
Artificial recharge	0
Brackish water desalination	-1
Sea water desalination	-1
Rainwater harvesting for irrigation of urban green	-1
Agricultural reuse of treated wastewater within the governorate (existing agriculture, SWAP)	-1
Agricultural Drainage Reuse	-1

II. Meeting MDGs for water

Strategy	Impact
Increase in tariff (5% per year for 5 years)	4
Minimization of physical and commercial losses from distribution network	4
Improving household water use efficiency (a reduction of 25% realized over a 5 year period)	4
Reuse of treated wastewater in urban green areas	1
Agricultural reuse of treated wastewater at ASDCO site (new agriculture)	1
Reuse of treated wastewater in green areas along highways and in the cities green belt	1
Grey Water Reuse for irrigation	1
Agricultural reuse of treated wastewater at Hamam site (new agriculture)	1
Irrigation of urban green areas with groundwater	1
Artificial recharge	1
Brackish water desalination	1
Sea water desalination	1
Rainwater harvesting for irrigation of urban green	1
Agricultural reuse of treated wastewater within the governorate (existing agriculture, SWAP)	1
Agricultural Drainage Reuse	1

c. Environmental Indicators:

I. Water Quality of Lake Mariout

Strategy	Impact
Increase in tariff (5% per year for 5 years)	0
Minimization of physical and commercial losses from distribution network	0
Improving household water use efficiency (a reduction of 25% realized over a 5 year period)	0
Reuse of treated wastewater in urban green areas	1
Agricultural reuse of treated wastewater at ASDCO site (new agriculture)	2
Reuse of treated wastewater in green areas along highways and in the cities green belt	2
Grey Water Reuse for irrigation	2
Agricultural reuse of treated wastewater at Hamam site (new agriculture)	3
Irrigation of urban green areas with groundwater	0
Artificial recharge	0
Brackish water desalination	0
Sea water desalination	0
Rainwater harvesting for irrigation of urban green	0
Agricultural reuse of treated wastewater within the governorate (existing agriculture, SWAP)	0
Agricultural Drainage Reuse	0

II. CO2 Emissions:

Strategy	Impact
Increase in tariff (5% per year for 5 years)	0
Minimization of physical and commercial losses from distribution network	0
Improving household water use efficiency (a reduction of 25% realized over a 5 year period)	0
Reuse of treated wastewater in urban green areas	-1
Agricultural reuse of treated wastewater at ASDCO site (new agriculture)	-1
Reuse of treated wastewater in green areas along highways and in the cities green belt	-1
Grey Water Reuse for irrigation	-1
Agricultural reuse of treated wastewater at Hamam site (new agriculture)	-1
Irrigation of urban green areas with groundwater	-1
Artificial recharge	-2
Brackish water desalination	-2
Sea water desalination	-2
Rainwater harvesting for irrigation of urban green	-1

Agricultural reuse of treated wastewater within the governorate (existing agriculture, SWAP)	-1
Agricultural Drainage Reuse	-1

d. Technical Indicators:

I. Volumes produced/saved:

Strategy	Impact
Increase in tariff (5% per year for 5 years)	2
Minimization of physical and commercial losses from distribution network	2
Improving household water use efficiency (a reduction of 25% realized over a 5 year period)	2
Reuse of treated wastewater in urban green areas	1
Agricultural reuse of treated wastewater at ASDCO site (new agriculture)	3
Reuse of treated wastewater in green areas along highways and in the cities green belt	1
Grey Water Reuse for irrigation	1
Agricultural reuse of treated wastewater at Hamam site (new agriculture)	3
Irrigation of urban green areas with groundwater	1
Artificial recharge	-1
Brackish water desalination	2
Sea water desalination	5
Rainwater harvesting for irrigation of urban green	1
Agricultural reuse of treated wastewater within the governorate (existing agriculture, SWAP)	3
Agricultural Drainage Reuse	4

The values assigned to the options in the table above are linked to the potential amounts discussed earlier in this report. The only negative sign in the above table is assigned to the artificial recharge option as the water recharged will not be completely recovered.

II. Narrowing the gap in household per capita consumption:

Strategy	Impact
Increase in tariff (5% per year for 5 years)	5
Minimization of physical and commercial losses from distribution network	1
Improving household water use efficiency (a reduction of 25% realized over a 5 year period)	4
Reuse of treated wastewater in urban green areas	0
Agricultural reuse of treated wastewater at ASDCO site (new agriculture)	0
Reuse of treated wastewater in green areas along highways and in the cities green belt	0
Grey Water Reuse for irrigation	0

Agricultural reuse of treated wastewater at Hamam site (new agriculture)	0
Irrigation of urban green areas with groundwater	0
Artificial recharge	0
Brackish water desalination	0
Sea water desalination	0
Rainwater harvesting for irrigation of urban green	0
Agricultural reuse of treated wastewater within the governorate (existing agriculture, SWAP)	0
Agricultural Drainage Reuse	0

III. Recycle factor :

The "Recycle factor" is defined here as "the ratio of the amount of water abstracted from a source to the amount of recovery for re-use".

Strategy	Impact
Increase in tariff (5% per year for 5 years)	0
Minimization of physical and commercial losses from distribution network	0
Improving household water use efficiency (a reduction of 25% realized over a 5 year period)	0
Reuse of treated wastewater in urban green areas	3
Agricultural reuse of treated wastewater at ASDCO site (new agriculture)	3
Reuse of treated wastewater in green areas along highways and in the cities green belt	3
Grey Water Reuse for irrigation	3
Agricultural reuse of treated wastewater at Hamam site (new agriculture)	3
Irrigation of urban green areas with groundwater	4
Artificial recharge	-1
Brackish water desalination	3
Sea water desalination	4
Rainwater harvesting for irrigation of urban green	4
Agricultural reuse of treated wastewater within the governorate (existing agriculture, SWAP)	3
Agricultural Drainage Reuse	4

IV. Non-revenue Water:

Non-Revenue Water	
Strategy	**Impact**
Increase in tariff (5% per year for 5 years)	0
Minimization of physical and commercial losses from distribution network	5
Improving household water use efficiency (a reduction of 25% realized over a 5 year period)	5
Reuse of treated wastewater in urban green areas	0
Agricultural reuse of treated wastewater at ASDCO site (new agriculture)	0

Reuse of treated wastewater in green areas along highways and in the cities green belt	0
Grey Water Reuse for irrigation	0
Agricultural reuse of treated wastewater at Hamam site (new agriculture)	0
Irrigation of urban green areas with groundwater	0
Artificial recharge	0
Brackish water desalination	0
Sea water desalination	0
Rainwater harvesting for irrigation of urban green	0
Agricultural reuse of treated wastewater within the governorate (existing agriculture, SWAP)	0
Agricultural Drainage Reuse	0

V. Water use from renewable freshwater sources:

Strategy	Impact
Increase in tariff (5% per year for 5 years)	1
Minimization of physical and commercial losses from distribution network	1
Improving household water use efficiency (a reduction of 25% realized over a 5 year period)	1
Reuse of treated wastewater in urban green areas	2
Agricultural reuse of treated wastewater at ASDCO site (new agriculture)	2
Reuse of treated wastewater in green areas along highways and in the cities green belt	2
Grey Water Reuse for irrigation	2
Agricultural reuse of treated wastewater at Hamam site (new agriculture)	2
Irrigation of urban green areas with groundwater	-1
Artificial recharge	1
Brackish water desalination	-1
Sea water desalination	5
Rainwater harvesting for irrigation of urban green	-1
Agricultural reuse of treated wastewater within the governorate (existing agriculture, SWAP)	2
Agricultural Drainage Reuse	1

In the above table, a negative sign has been assigned to values corresponding to options that will have a direct effect of exhausting renewable fresh water such as Nile Water which is represented in drinking water and groundwater.

e. Energy Indicators:

I. Energy consumed in the water sector per unit drinking water volume produced (Specific Energy/m3):

Strategy	Impact
Increase in tariff (5% per year for 5 years)	0
Minimization of physical and commercial losses from distribution network	0
Improving household water use efficiency (a reduction of 25% realized over a 5 year period)	0
Reuse of treated wastewater in urban green areas	-1
Agricultural reuse of treated wastewater at ASDCO site (new agriculture)	-1
Reuse of treated wastewater in green areas along highways and in the cities green belt	-1
Grey Water Reuse for irrigation	-1
Agricultural reuse of treated wastewater at Hamam site (new agriculture)	-1
Irrigation of urban green areas with groundwater	-1
Artificial recharge	-2
Brackish water desalination	-2
Sea water desalination	-4
Rainwater harvesting for irrigation of urban green	-1
Agricultural reuse of treated wastewater within the governorate (existing agriculture, SWAP)	-1
Agricultural Drainage Reuse	-2

f. The Integration Indicator:

This indicator reflects the potential of each option in its ability to integrate with other options and indicator values assigned to all options will have either a positive sign, which reflects the degree of integration foreseen for each particular strategy, or zero, which indicates that integration is likely to be less feasible.

Strategy	Impact
Increase in tariff (5% per year for 5 years)	1
Minimization of physical and commercial losses from distribution network	1
Improving household water use efficiency (a reduction of 25% realized over a 5 year period)	1
Reuse of treated wastewater in urban green areas	2
Agricultural reuse of treated wastewater at ASDCO site (new agriculture)	2
Reuse of treated wastewater in green areas along highways and in the cities green belt	2
Grey Water Reuse for irrigation	1
Agricultural reuse of treated wastewater at Hamam site (new agriculture)	1
Irrigation of urban green areas with groundwater	1
Artificial recharge	1
Brackish water desalination	1
Sea water desalination	2
Rainwater harvesting for irrigation of urban green	1
Agricultural reuse of treated wastewater within the governorate (existing agriculture, SWAP)	2

g. Overall scoring:

Table 10 shows the average value that each strategic option scored with respect to the individual indicators identified.

Strategy	Average
Increase in tariff (5% per year for 5 years)	1.461538
Improving household water use efficiency (a reduction of 25% realized over a 5 year period)	1.461538
Minimization of physical and commercial losses from distribution network	1.076923
Agricultural reuse of treated wastewater at ASDCO site (new agriculture)	0.923077
Agricultural reuse of treated wastewater at Hamam site (new agriculture)	0.846154
Agricultural reuse of treated wastewater within the governorate (existing agriculture, SWAP)	0.692308
Reuse of treated wastewater in green areas along highways and in the cities green belt	0.615385
Reuse of treated wastewater in urban green areas	0.538462
Sea water desalination	0.538462
Agricultural Drainage Reuse	0.538462
Grey Water Reuse for irrigation	0.461538
Irrigation of urban green areas with groundwater	0
Rainwater harvesting for irrigation of urban green	-0.15385
Brackish water desalination	-0.30769
Artificial recharge	-0.76923

Table.10 Average scores with respect to all indicators

These are shown in descending order and therefore the most appropriate strategic options are the ones that yield the higher average scores.

8. Institutional Mapping:

a. Current Institutional map:

The Governorate of Alexandria is the leading executive and administrative body of Alexandria.

The Ministry of Housing is responsible for all water supply and sanitation services in Alexandria.

The Holding Company for Waste Water, which lies under the Ministry of Housing, is the National Organization for Potable Water & Sanitary Drainage which covers water supply and sanitation to all the governorates in Egypt. It is the umbrella under which all local governorate drinking water and sanitation companies carry out their operations.

b. Ability to achieve proposed Strategies:

Although, the current institutional structure shares a reasonable degree of fit with that envisaged as part of this current Strategic IUWM plan, more flexibility in the legislation process would doubtlessly help towards making more of the potential strategic options feasible, particularly those related to the re-use of treated waste water in irrigation for example.

c. Suggested Institutional Arrangement:

Whilst it is well recognized that the existing institutional arrangement is well organized, there are a number of refinements to this that would greatly benefit the transition to a best practice, sustainable management structure. The fact, for example that ASDCO currently receives its revenues through AWCO could restrict ASDCO's decision making process compared to those of AWCO's. ASDCO could potentially benefit from greater future financial independency which would assist them to be in a position to fund more wastewater treatment plants in a manner that could enhance the potential to re-use by distributing treated waste water to agriculture to supplement Nile Water currently used in

irrigation, as discussed in this report and hence provide a further level of income either by direct or indirect payment for this service.

An additional process that is seen to have a potentially significantly boost the implementation of this Strategic Plan is the establishment of a Governorate level Inter-ministerial Committee to act as a link between national and local decision makers. This approach has proved successful in four other Egyptian governorates including the neighboring Behira Governorate.

One other process that could potentially benefit the implementation of this plan, is to in some form maintain the current success achieved by the LA by establishing an Advisory Committee or Group from former LA members as this would be considered an important catalyst in achieving a Sustainable Integrated Water Management process in the Governorate.

9. Implementation Plan:

a. Timeline for Implementation:

Table 11 shows the proposed timeline for implementation of the Strategic Plan.

Action	2011	2013	2015	2017	2019	2021	2023	2025	2027	2029	2030
Launching and promoting plan	x										
Advisory Group (LA) Evolution		x	x								
Establishment of a governorate level Inter-ministerial committee	x	x	x	x	x	x					
Resolving legal problems related to using treated waste water in irrigation	x	x	x	x	x	x					
Increasing tariff				x	x	x	x	x			
Reducing physical losses and increasing household efficiency				x	x	x	x	x	x		
Expansion in Agricultural drainage reuse										x	
Expansion in sea water desalination											x

Table.11. proposed timeline for implementation

b. Constraints & Risk Assessment:

One of the most significant strengths of this Strategic Plan is thought to be the fact that it has been researched under the close supervision of all of the decision makers (Key Stakeholders) in the Alexandria Water Sector who were part of the SWITCH Learning Alliance; therefore any significant institutional changes could affect the activities that this plan suggests. However, it is considered that the strategic options and the validity of the research will prove to be a starting point for any new

government structures that may evolve and an early start would undoubtedly prove to be useful in getting the key decision makers committed to the activities proposed by this study

c. M&E Plan and key factors:

It is proposed that the M&E plan will focus on particular criteria which are envisaged to be among the principle benefits derived by adopting the strategic options selected for this plan. These criteria are:

I. Economic Criteria:
   1. Full Cost Recovery.
   2. Better Water Supply-Wastewater Budget balance; as currently the Waste Water Company only receives a portion of the gross income made by the Water Company.

II. Social Inclusion Criteria:
   1. Security of service; especially to new communities and informal settlements.
   2. Governance:
      a. Information made availability for Local Communities
      b. Shared Data Systems between AWCO and ASDCO
      c. Measuring Governance using internal metrics according to "Best Management Practice Benchmarking – Egypt"
      d. Measuring Governance using external metrics according to "Best Management Practice Benchmarking - Mediterranean Region (Or better still this could be against the Water and Sanitation International Benchmarking Network (IBNET) sponsored by the World Bank (WB))
      e. Promoting Consultative and Participatory approaches to water related problem solving.

III. Environmental Criteria:

1. Environmental Impact: the quality of water in Lake Maryut will be assessed as the progress in waste water treatment continues, also carbon emissions resulting from every strategic option will be calculated.

IV. Technical Criteria:

1. System-wide improvements
    a. Leakage reduction
    b. Infiltration; which relates to the overall water quality of treated effluent and particularly saline water infiltration.
    c. Recovery rate: This is the rate of sewage collected from the total amount of water put into supply.

V. Energy Criteria:

1. Specific Energy Consumed: one of the aims of the monitoring plan will be tracking the energy consumption associated with different strategic options in a and provide best cost options.

References

AbuZeid, K.M., Smout, I., Taha, H., Sabry, N., Elrawady, M. 2010, Alexandria Water Demand Management Study, CEDARE and Alexandria Water Company (AWCO), March 2010.

AbuZeid, K.M, El Arabi, N., Fekry, A., Meneum, M.A., Taha, K. and El Karamany, S., Elrawady, M. 2009. Assessment of Groundwater Potential in Alexandria Governorate, CEDARE and Research Institute for Groundwater, November 2009.

AbuZeid, K.M., Assimacopoulos, D., Manoli, E., Donia, N., Sabry, N., Ramadan, A., Elrawady, M. 2010a, Alexandria Urban Water System Modeling, CEDARE and National Technical University of Athens, Alexandria Water Company, March 2010.

AbuZeid, K.M., Van Der Steen, P., Hellaly, H., Kassem, A., Elrawady, M. 2010b, Alexandria wastewater treatment and reuse study, CEDARE and Alexandria Sanitary Drainage Company (ASDCO), UNESCO-IHE, March 2010.

AbuZeid, K.M., Shoutes,B., Yaseen, A., Alshafie, A., Elrawady, M. 2010, Alexandria storm water management Study, CEDARE and Alexandria University (AWCO), March 2010.

AbuZeid, K., Elrawady, M. 2010, Institutional Mapping and Water Governance Analysis in the City of Alexandria, CEDARE, March 2010.

Chemonics Egypt, 2010, Affordability Assessment to Support the Integrated Urban Water Management in Alexandria – January 2011.

GTZ, 2004, New practice of participatory local development in Egypt's urban areas, Policy paper, GTZ, Cairo

Intergovernmental Panel on Climate Change (IPCC). (2007). Working Group I: The Physical Science Basis, Technical Summary: The Fourth Assessment Report of the Intergovernmental Panel on Climate Change pp. 21-87.

Intergovernmental Panel on Climate Change (IPCC). (2001). Working Group II: Impacts, Adaptation and Vulnerability African region: The third Assessment Report of the Intergovernmental Panel on Climate Change pp. 489-525.

Saad, M. , Future water availability in Alexandria, Ministry of Water Resources and Irrigation (MWRI), August 2010.

Retamal, M.L & White, S. 2010, Integrated Supply-Demand Planning for Alexandria, Egypt, Water efficiency study &business case analysis for water demand management, CEDARE and ISF-UTS, March 2011.