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INTEGRATED SUPPLY-DEMAND PLANNING FOR ALEXANDRIA, EGYPT

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INTEGRATED SUPPLY-DEMAND PLANNING FOR ALEXANDRIA, EGYPT

Water efficiency study & business case analysis for water demand management

Draft

For EU-SWITCH / CEDARE

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DISCLAIMER

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EXECUTIVE SUMMARY

Water availability in Egypt is highly constrained, due to its dependence on a fixed national share of the Nile River basin and population growth. This study, funded by the EU under the SWITCH program, has been assessing urban water demand in Alexandria and options to maintain the supply-demand balance, ranging from water efficiency options to effluent reuse and supply options such as desalination. This analysis was undertaken using an integrated resource planning framework. The need for new institutional frameworks has been identified, including national regulation of appliance efficiency and local regulation of new buildings and developments. Indicative costing of options suggest that there are some highly cost-effective options, particularly water efficiency options, that could be the subject of investment.

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1 INTRODUCTION

The cities and towns in Egypt operate in a highly constrained water supply situation, due to the dependence on a fixed national share from the Nile River basin (shared by 10 riparian countries), and a diminishing per capita share as population increases. As part of the European Union-funded SWITCH project, the authors have undertaken research on the urban water supply-demand balance in Alexandria, the second largest city in Egypt.

STUDY AIM

The aim of this study is to develop and model a portfolio of options to meet the projected demand for water in 2037 in Alexandria while maintain extractions from the Nile system at a capped amount. The options available include a range of demand management and supply options and include pricing, regulatory and engineering options.

The study is also designed to present a business case for investment in options that improve the efficiency of water use, by improving on previous estimates (Turner et al. 2008) and demonstrating the cost effectiveness of these options relative to the cost of supplying water.

A user-friendly model for assessing options for water demand management and supply has been developed, and populated with the best available information regarding water use by sector and by end use, and also shows the capital and operating costs, and the estimated yield of the various options in a transparent way.

This report also describes a number of implementation issues associated with the options, including equity issues, financing and the additional benefits that can be derived from a number of the options.

PREVIOUS STUDIES FOR ALEXANDRIA

In 2007 and 2008 the Institute for Sustainable Futures (ISF) conducted action research and training workshops in Cairo and Alexandria on the method of integrated resource planning as applied to urban water. During these workshops, preliminary data was gathered regarding household water use, potential options for demand management in Alexandria and the cost of these options. A preliminary model was set up to estimate the relative costs of these options. In 2010, ISF and CEDARE set out to undertake a more comprehensive business case analysis of both demand management and supply options.

Through the SWITCH program in Alexandria, a comprehensive range of studies have been undertaken by the Learning Alliance (comprising a range of stakeholder agencies including AWCO, ASDCO, CEDARE, the Governorate of Alexandria and the University of Alexandria) regarding water management, including groundwater management and supply options, stormwater and rainwater options, demand management, household water survey, social impacts & affordability and these culminated in the development of an integrated urban water management plan (please see AbuZeid et al. 2009, 2010a, 2010b; Chemonics Egypt,

2010; Yassin, 2010).. The results of these studies have been reviewed and where possible, integrated into the modeling and results in this report.

THE INTEGRATED RESOURCE PLANNING PROCESS

Integrated resource planning (IRP) has its origins in the electricity industry in the 1980's, with the recognition that it is often cheaper and quicker to reduce the demand for electricity than it is to build new power stations. The principles underlying IRP include the idea that reliable reductions in demand can be considered as equivalent to increases in supply, and the task is therefore to determine what options are available to increase the efficiency of water use, and to estimate the relative costs and benefits of a range of options to meet the objectives of a water agancy or utility. These objectives are often driven by an emerging gap between the demand for water and the available supply or yield.

The process of IRP includes the development of a baseline, or reference case demand forecast. This forecast is then used to determine the new supply-demand balance in the case where demand management options are implemented. The development of options that involve the reduction of water demand through improved water efficiency requires a greater level of analysis of the demand for water by sector (e.g. residential, commercial, industrial) or by end use (e.g. toilets, showers, washing machines, garden use). This is called sector and end use analysis, and can be undertaken with varying levels of detail depending on data availability. Other aspects of the process of integrated resource planning are described in Turner et al. (2006).

This methodology and process has been applied in a number of areas worldwide, including in Australia and also in the Middle East (Turner et al. 2008, Turner et al. 2005). The process is summarized in the diagram below (Figure 1).

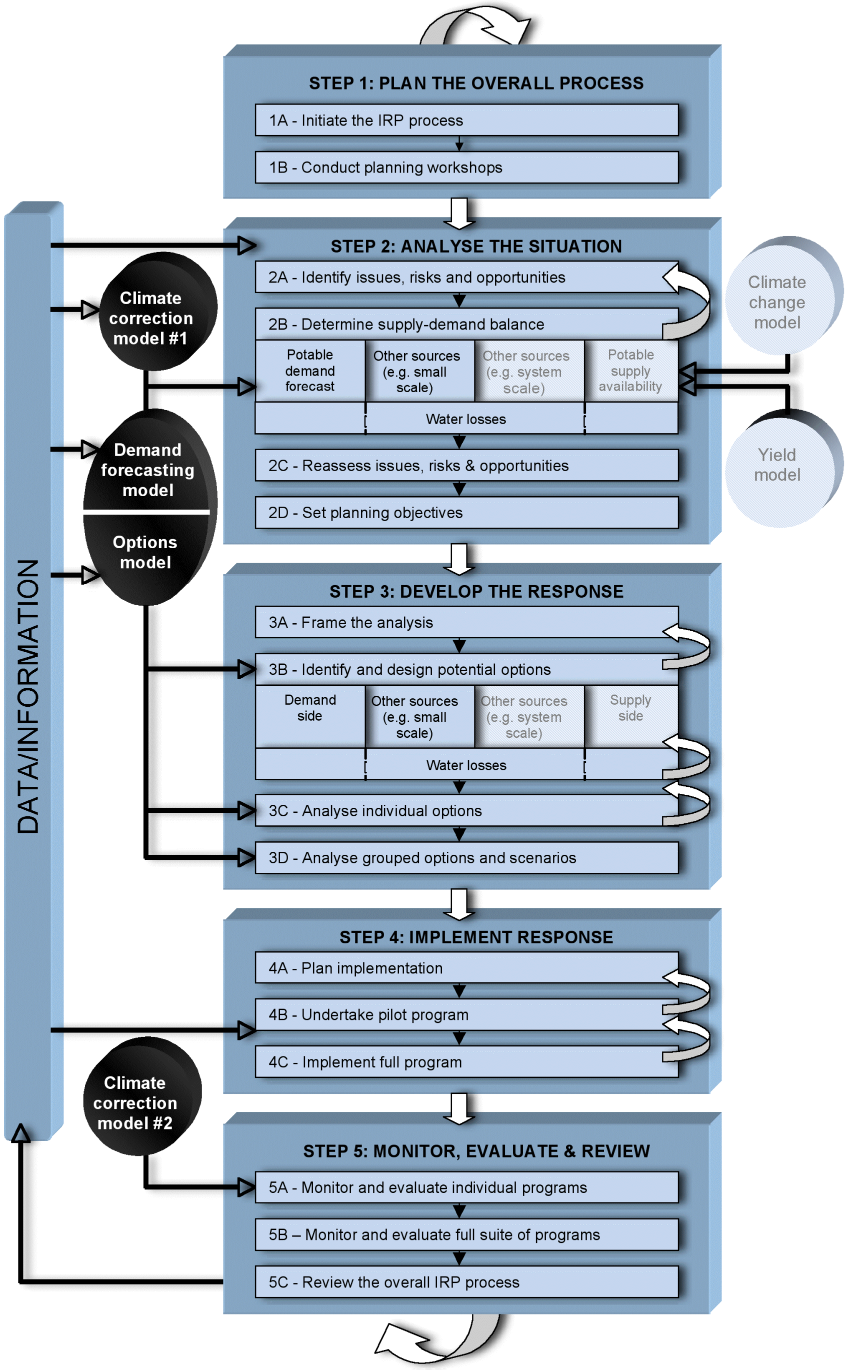


Figure 1 The steps in the Integrated Resource Planning Process (Turner et al. 2006, 2008).

THIS WATER SUPPLY-DEMAND PLANNING STRATEGY

This study has been undertaken as a modified or simplified version of Steps 1, 2 and 3 in the diagram above. The workshops that were conducted in 2007 and 2008 covered some of the areas associated with planning the process, and also identifying constraints and establishing a supply-demand balance. The process of developing a demand forecast and the analysis of yield has been based on the best available information, including the results of a household survey, but has been primarily a desktop analysis. Nonetheless, the results are useful for the

purpose of identifying the underlying issues and constraints and a portfolio of options to meet the supply demand balance and increase the level of sustainability of water use in Alexandria.

In addition to a literature review of these studies, the ISF team visited Alexandria and Cairo with CEDARE to meet with the Alexandria Water Company (AWCO) and the Alexandria Sanitation and Drainage Company (ASDCO) to discuss possible options and gather information regarding infrastructure planning and costs.

The information gathered through the training workshop, literature review and interviews were used to build upon the preliminary model in order to develop an integrated water supply/demand planning strategy including business case analyses of potential options. The integrated water supply/demand planning strategy involved an analysis of household end use data (from the household water use survey), analysis of historical water consumption by sector, water use projections to 2037, development of demand management and supply options and calculation of water savings and levelised costs.

2 BACKGROUND

The allocation of the Nile River resources to Egypt is based on a 1959 agreement with Sudan that allocates 55 billion m3 to Egypt. This is supplemented by very small volumes of water from other sources. The majority of water is used in agriculture, although the cost of supplying water to urban areas is high due to capital costs for treatment and reticulation. Egypt is an arid country, and Alexandria is at the very end of an extensive system of canals that provide water for agriculture, industry and urban uses.

Water supply in the region is the responsibility of the Alexandria Water Company (AWCO). Wastewater management is undertaken by a separate agency: the Alexandria Sanitation and Drainage Company (ASDCO). In addition, overall national planning and funding support for capital works is administered by the Egypt Holding Company for Water and Wastewater.

3 IDENTIFICATION OF OPTIONS

BACKGROUND

PROGRAMS PREVIOUSLY STUDIED BY ISF

During the 2007 and 2008 training workshops a series of options were developed and examined by ISF. These options were based on preliminary estimates developed from workshop participants (members of the Learning Alliance) and also the knowledge of the workshop leaders, based on experience in Australia and also in other countries in the Middle East (Oman, Jordan). These estimates were based on limited information, but were reality tested against similar results in other locations. The outcome of this work is shown in Table 1 below.

Options	Option cost PV $m	Unit costs PV$/PVm3	Water saved or supplied in 2037 (mM3/a)
Demand Management Options			
Existing properties			
Displacement device program	1.4	0.06	2.0
Toilet replacement program	24	0.29	7.3
Household leaks program	6.7	0.07	8.4
Tourist and commercial program	3.3	0.08	3.8
Government program	2.7	0.08	3.1
Industry program	2.8	0.08	3.2
Non revenue water program	66	0.14	4.1
Sub Total	108	*0.11	69
New properties			
Household regulations	163	0.45	91
Supply options			
Desalination	542	1.22	50
Major industrial reuse	126	1.42	10

Table 1 Estimates of present value (PV) cost in USD, unit cost (levelised) and yield of a number of demand management and supply options, as estimated in action research and training workshops in 2007 and 2008.

All of the above options have subsequently been refined and incorporated into the current study.

PROGRAMS EXAMINED IN THE ALEXANDRIA WATER COMPANY (AWCO) WDM STUDY

A range of options were examined in the Alexandria Water Demand Management Study. The following options were devised by AWCO and CEDARE and assessed qualitatively through multi-criteria analysis. The three options which received the highest scores were then examined in more detail. These were options 1, 5 and 9 from the following list.

1 – Minimise losses from the pipe network

2 - Regular detailed monitoring of production, transfers to other areas, demand and losses

3 – Maximise water use efficiency in commercial premises

4 – Maximise industrial water use efficiency

5 – Maximise household water use efficiency

6 – Use alternative water sources for some water uses

7 – Capacity building of Alexandria water company in WDM

8 – Co-ordination with the Ministry of water resources and irrigation MWRI – improved efficiency in agriculture could lead to a higher allocation for the city of Alexandria

9 – Increase water tariff

10 – Awareness and enforcement of laws – community education

The costing estimates determined for options 1, 5 and 9 in the WDM study were used to inform the costing of options in this integrated resource planning study. The concepts for options 3, 4, 6 and 8 were also incorporated into this study. While options 2 and 7 were also considered important strategies, due to difficulties in determining water savings, they were not included in the present analysis.

4 DEMAND MANAGEMENT OPTIONS

DM1 - HOUSEHOLD WATER SAVING FITTINGS RETROFIT

DESCRIPTION

This program involves employing plumbers and representatives from the water company to visit households and undertake several key water saving tasks. These include;

1. Fixing leaks in the plumbing, particularly toilet cistern leaks
2. Replacing old showerheads with new water efficient showerheads
3. Fitting a displacement device into toilet cisterns to reduce the volume used when flushing
4. Installing aerators on taps to reduce the flow rate

Evaluations of similar programs in Australia found water savings around 20 kilolitres / household / annum for average household size of 2.7 (Turner et al. 2007). The costs for this option have been based on costing developed by AWCO (AbuZeid et al., 2010b).

DM2 - TOILET REPLACEMENT IN HOUSEHOLDS

DESCRIPTION

This option involves employing plumbers to visit households and replace their old toilets completely. When old 12 litre flush toilets are replaced with new 4.5 litre / 3 litre dual flush toilets, significant water savings can be achieved in the household.

DM3 - TOURIST AND COMMERCIAL EFFICIENCY IMPROVEMENTS

DESCRIPTION

The large hotels and coastal resorts in Alexandria use significant volumes of water, not just in guest rooms but also in associated restaurants and facilities such as gardens and pools. This program involves conducting audits of hotels and other major tourist/ commercial facilities to determine where efficiencies can be made and then conducting retrofits. A typical retrofit might involve fixing leaks throughout a hotel, upgrading irrigation systems to those which use less water, replacing old showerheads with new efficient ones, installing tap aerators to reduce flow rates, installing toilet displacement devices, conducting maintenance on cooling towers and advising on cleaning practices, such as the style and frequency with which cleaning is undertaken, or how often gardens are watered. A similar program conducted by Sydney Water on a range of hotels in Sydney found that this program on average saved 20% of the water used previously (Sydney Water, 2010).

DM4 - GOVERNMENT BUILDINGS EFFICIENCY IMPROVEMENTS

DESCRIPTION

This option involves carrying out audits and retrofits on government and other institutional buildings including schools and educational facilities as well as government departments and offices. Changes conducted as part of the program may include fixing leaks, installing tap aerators, installing toilet displacement devices to reduce flush volume, conducting maintenance on cooling towers and modifying cleaning practices to use water more efficiently. Similar programs carried out in Australia found savings between 10-20% of the original consumption (Sydney Water, 2010).

DM5 - INDUSTRIAL CUSTOMERS EFFICIENCY IMPROVEMENT

DESCRIPTION

This program would require a representative of AWCO to carry out audits of industrial facilities to determine where efficiency gains can be made. The use of water in industrial facilities can be quite distinct depending on the type of process, however in general, efficiency gains can be made through changes to practices, changes to operational settings or through changes to infrastructure or upgrading equipment. The facility audit and a subsequent water saving strategy would need to be established in collaboration with the business owner.

DM6 - SYSTEM LEAKAGE REDUCTION

DESCRIPTION

This program aims to reduce leakage in the city's water supply network. To do this, AWCO would need to purchase leak detection equipment and ultrasonic flow meters to monitor each zone in the network so that leaks can be identified and repaired. Currently, non-revenue water represents 36% of AWCO's bulk water

consumption. It is expected that approximately half of this amount (~18%) represents physical losses from the network. So this program is likely to make significant water savings. This option has been modelled on the one examined in the AWCO 2010 report, which estimated that it will take 10 years for such a program to carry out works on the entire network. In reality, leak detection and repair is likely to be an ongoing program, so that once the program is complete, it will need to be started again.

DM7 - TARIFF REFORM

DESCRIPTION

The water affordability study prepared by Chemonics Egypt (2010) indicates that there is significant scope to increase water use tariffs while remaining within affordable limits. Currently, a typical water bill represents around 2% of an average salary; this initiative would lift the water tariffs to around 4% of an average salary, assuming that demand did not decrease. However, this price increase is expected to result in behaviour change regarding discretionary water use and an associated reduction in demand. It may even provide an incentive for householders to fix leaks and / or change appliances.

There are reasonable concerns regarding equity issues associated with increasing water prices. It is worth noting however, that the equity impacts can be offset by the implementation of the other options in the portfolio of water efficiency options, which will all have the effect of reducing overall household water demand by more than the price increase. One option is to target poorer neighbourhoods for the initial implementation of water efficiency options first, in a similar way to the roll-out of the water saving program in Maawa El Sayadeen.

DM8 - AGRICULTURAL EFFICIENCY OFFSETS

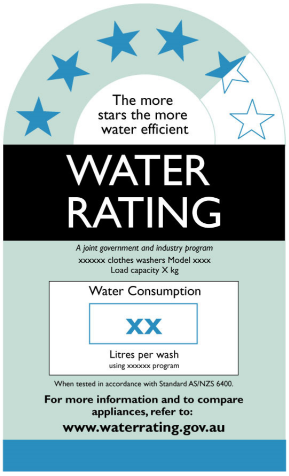
DESCRIPTION

This program would require collaboration between the Alexandria Water Company and the Ministry of Water Resources and Irrigation. The initiative involves upgrading irrigation systems in agricultural areas upstream of Alexandria, resulting in water savings, which can then be used to increase the city's water supply allowance from the Nile. In this option, AWCO would pay for the irrigation upgrades, enabling them to claim the water savings. There may be significant potential in this option, as upgrading irrigation systems is relatively inexpensive when compared with supply side options, for example, and the option can be expanded to encompass any agricultural land upstream.

DM9 - APPLIANCE EFFICIENCY REGULATION

DESCRIPTION

This option involves government regulation of the appliances and fittings that may be sold in Egypt and would need to be implemented at the national level. Inefficient appliances would be banned from sale within Egypt, so that as fittings and appliances are replaced, efficiency will improve across the country. This option would be coupled with a labelling scheme, where all products are displayed with a label indicating the water use of a product. This would then enable consumers to compare products when purchasing and choose a more efficient model if they are interested in saving money on water bills.



5 SUPPLY OPTIONS

S1 – WASTEWATER RECYCLED FROM WEST WWTP AND EAST WWTP FOR INDUSTRIAL USE

DESCRIPTION OF OPTION

In this option, the Western wastewater treatment plant (WWTP) would be upgraded to recycle wastewater so that it is suitable for reuse in industrial facilities. A new pipeline and pumps would be required to transport recycled water from the western WWTP to the industrial areas. The map in Figure 2 shows the concept for this supply option. The areas coloured in light purple are assumed to represent major industrial areas where recycled water would be used.

Figure 2 Concept for water recycling option supplying water to industrial zones in Alexandria

S2 - WASTEWATER RECYCLED FROM WEST WWTP AND EAST WWTP FOR AGRICULTURAL USE

DESCRIPTION OF OPTION

In this option, both the western and eastern wastewater treatment plants (WWTPs) are upgraded to recycle wastewater so that it is suitable for agricultural application. New pipelines and pumps would be required to transport recycled water from the eastern and western WWTPs to suitable agricultural areas. The concept for this option is illustrated in the map in Figure 3.

Figure 3 Concept for option to recycle wastewater for agricultural use in areas nearby to Alexandria City

S3 – DESALINATION OF AGRICULTURAL DRAINAGE WATER FOR AGRICULTURAL USE

DESCRIPTION OF OPTION

In this option, brackish agricultural drainage water would be extracted from the agricultural drain and treated in a desalination plant so that it is suitable for use in industrial facilities and as a non-potable supply source for coastal resorts. The concept for this option is illustrated in Figure 4, where the red dot marks the proposed location of the plant and the red lines represent the 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 in the Noubariya canal. This issue would need to be determined by the water supply and irrigation authorities. The brine resulting from this treatment process would require careful disposal. In this study it has been assumed that a separate pipeline would be used to discharge the brine into the ocean, however, the impacts of this will need to be studied more carefully to ensure there will be no adverse impacts on the coastal environment.

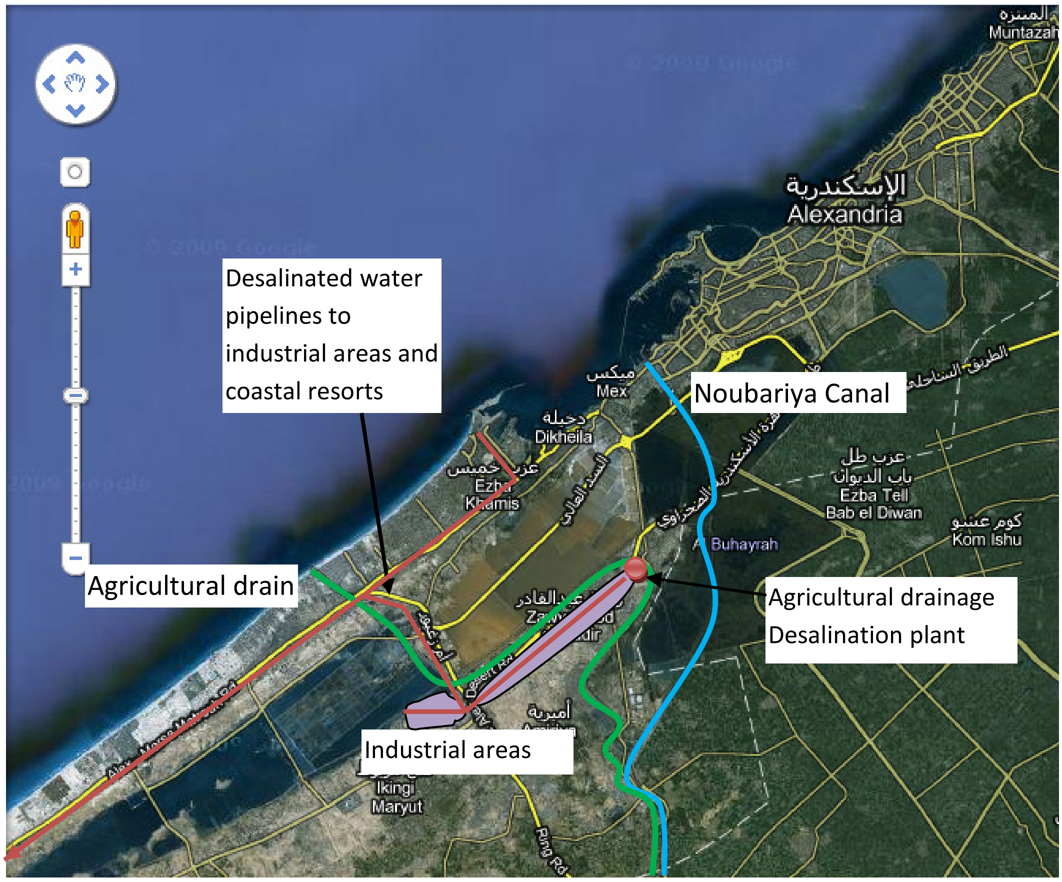


Figure 4 Concept for supply option S3 where brackish agricultural drainage water is desalinated for use in industrial areas and coastal resorts (note: the pipeline continues along the coastline to same extent as option S5)

S4 - GROUNDWATER FOR IRRIGATION OF CITY PARKS

DESCRIPTION OF OPTION

This option follows the scheme suggested in the groundwater potential report (Abu Zeid et al. 2009), where the use of low saline water is suggested for use in outdoor irrigation in Alexandria. The location of existing groundwater wells is shown in Figure 5, which provides an indication of the potential spread and location of wells for this option. Figure 6 shows the location of green areas within the city which would be irrigated by groundwater.

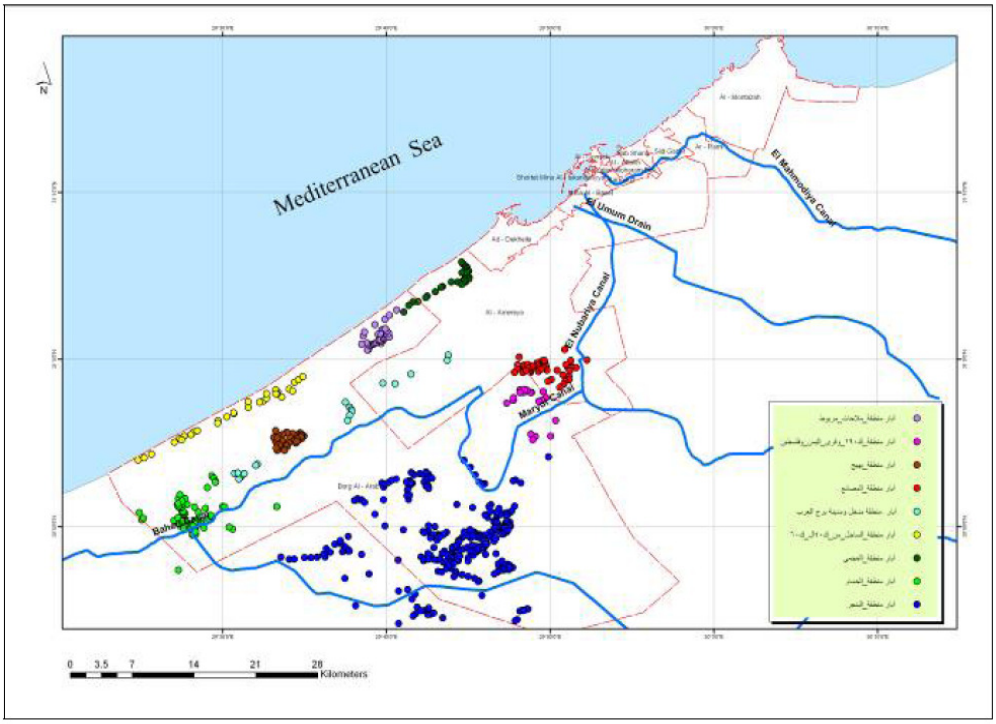


Figure 5 Location of existing groundwater wells (AbuZeid et al. 2009)

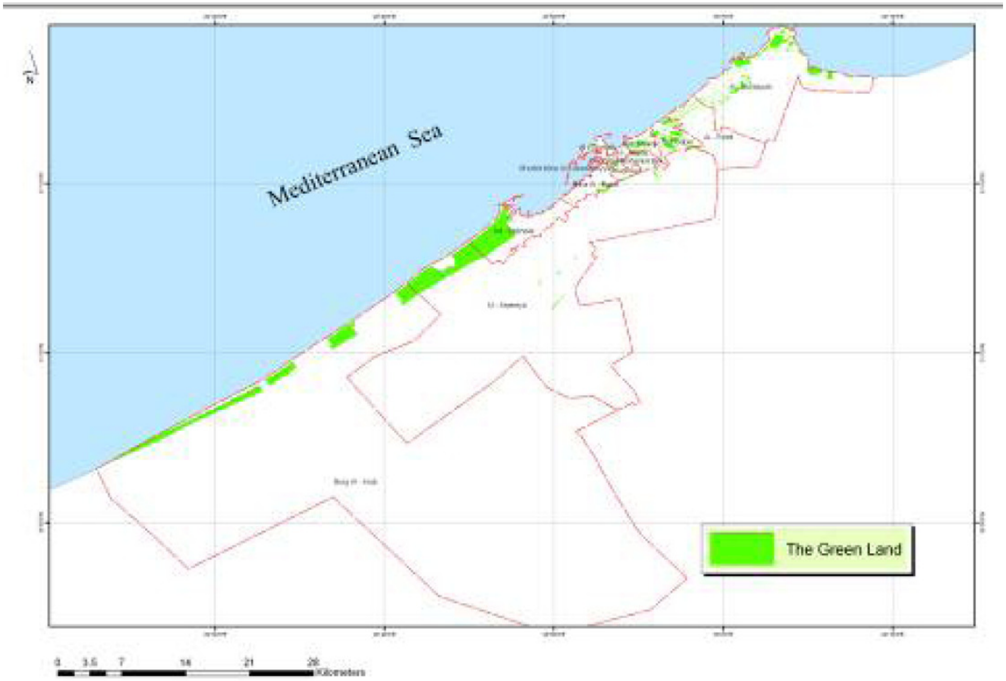


Figure 6 Potential irrigation zones for low saline groundwater (Abu Zeid et al. 2009).

S5 – DESALINATION OF SEAWATER FOR REUSE

DESCRIPTION OF OPTION

This option involves drawing seawater from the Mediterranean and treating it at a desalination plant on the coast amidst the coastal resorts on the western side of Alexandria. Desalinated water would be then be pumped in both directions along the coastline to supply water to all coastal resorts. This concept is illustrated in the map in Figure 7, where the red dot marks the assumed location of the plant and the red lines indicate the possible network supplying water to coastal resorts. This option assumes that desalinated water would be delivered to customers in a separate network, however, if the existing network can be modified it would be possible for the desalinated water to feed in to that network. This would reduce construction costs.

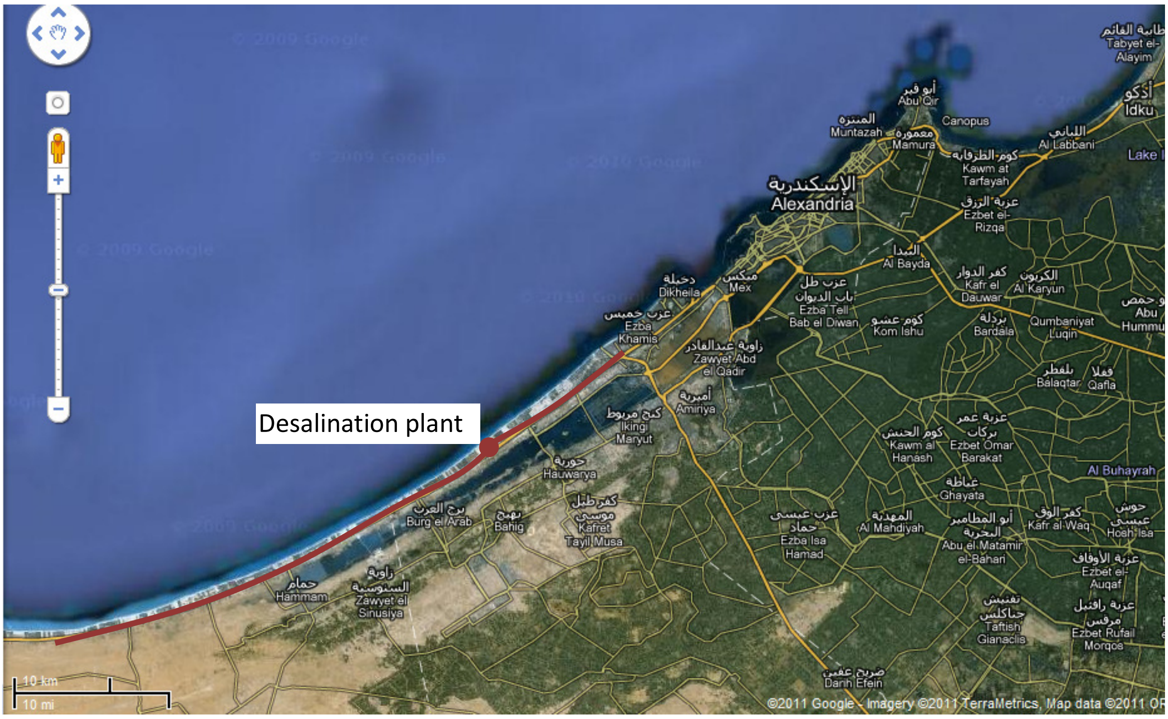


Figure 7 Concept for option S5 where desalinated water is used to supply coastal resorts

S6 – LOCAL WASTEWATER REUSE FOR NEW HOUSING DEVELOPMENTS

DESCRIPTION OF OPTION

This is a water supply and wastewater program that would involve all new housing areas. In this program, government regulations would require housing developers to install small scale pressurized sewer systems with local treatment to a recycled water standard. The recycled water would then be pumped back to households for non-potable use, such as toilet flushing, gardens, dust suppression and car washing. Houses would require dual reticulation to enable recycled water to be plumbed into toilets and outdoor taps. The benefit of a localized system is that both wastewater and the recycled water supply do not need to be pumped large distances, as the sewer is pressurised, pipes are smaller and can be buried in shallow trenches.

S7 – LOCAL WASTEWATER REUSE FOR NEW HOUSING DEVELOPMENTS WITH NUTRIENT RECOVERY

DESCRIPTION OF OPTION

This option is similar to option S6, with an added component. This option requires that all households are additionally fitted with urine separating toilets. The urine stream from the toilets is collected in underground tanks in the street, which are regularly pumped out by urine collection trucks. The trucks then take the urine to an agricultural facility where it is stored for 30 days for sterilization. After that point, the sterilized urine can either be dried and crystallized or kept in liquid form and sold as fertilizer for agriculture.

6 MODELLING THE SUPPLY-DEMAND BALANCE

An integrated supply-demand planning model was initially developed for Alexandria during the SWITCH training workshop in 2008. This model has been modified to incorporate a range of new information, including; a series of historical consumption data disaggregated by sector, new consumption projections, end use data collated through the household end use survey, new options and costing for options. The model has also been modified to make the model more user friendly with easily identifiable assumptions and inputs. The intention is that the model can now be used by Alexandria Water Company and any other relevant authorities to assist with water planning.

OPTION SUMMARY AND ASSUMPTIONS

Details of the demand management and supply options described in the previous section are summarised in Table 2. The option codes and names are shown in the left hand columns and the key assumptions used in modelling are shown in the right hand columns, regarding major infrastructure, water savings and costs.

Some of these options include variations which essentially target the same demands, which means that calculated water savings would overlap. To ensure that options are not competing, two slightly different scenarios (or portfolios) were developed to address the supply-demand gap in Alexandria. The furthest column on the right hand side of Table 2 indicates in which scenario the option has been used. The majority of options feature in both scenarios.

Table 2 Summary of options and assumption used in modelling

Code	Demand Management options	Costs included	Water savings	Participants	Scenario no.
DM1	Water saving fittings retrofit	Showerheads, tap fittings, toilet displacement device, car costs, program advertising, labour	30 m3/ household/ year	80% households	1, 2
DM2	Household toilet replacement program	Toilets, program advertising, car costs, labour	28 m3/ household/ year	20% households	1, 2
DM3	Tourist &	Based on estimated	20%	50% tourist /	1, 2

Code	Demand Management options	Costs included	Water savings	Participants	Scenario no.
	commercial audit & retrofit	cost of $1300/ ML/year		comm. properties	
DM4	Government buildings audit & retrofit	Based on estimated cost of, $1000/ ML/year	20%	80% government properties	1, 2
DM5	Industrial customers efficiency improvement	Based on estimated cost of $780/ ML/year	25%	50% industrial properties	1, 2
DM6	System leakage reduction	Leak detection equipment, ultrasonic flow meters, pressure recorders, car costs, staff training, computers, valves & other supplies, labour	Reduce losses to 240 L/connection /day (down from 372)	Entire network over 10 years	1, 2
DM7	Tariff reform	Administration costs	10%	All residential customers	1, 2
DM8	Agricultural efficiency offsets	Equipment, labour, administration costs	0.5 m3/m2/year	150,000,000 m2 agricultural land	1, 2
DM9	Appliance efficiency regulation	Appliance efficiency regulation	10% in each new house	All new households	1, 2
S1	Wastewater reuse for industrial	Wastewater recycling plant, pipe network, operational	88 ML/day	60% industrial demand	1

Code	Demand Management options	Costs included	Water savings	Participants	Scenario no.
	areas	labour, electricity use, maintenance & parts			
S2	Wastewater reuse for agriculture	Wastewater recycling plant, pipe network, operational labour, electricity use, maintenance & parts	172 ML/day	42,000,000m2 agricultural land close to the city	1, 2
S3	Agriculture drainage desalination & reuse	Brackish water desalination plant, pipe network, brine disposal pipeline, operational labour, electricity use, maintenance & parts	171 ML/day	50% tourist demand, 60% industrial demand	2
S4	Groundwater for green space irrigation	Construction of 840 wells, pipeline network, maintenance and operating costs	50 ML/day	Green areas along city coastline	1, 2
S5	Desalination for use in coastal resorts	Seawater desalination plant, pipe network, operational labour, electricity use, maintenance & parts	115 ML/day	70% tourist facilities demand	1
S6	Local wastewater reuse for new housing developments	Net cost for decentralized sewer system & localized recycling treatment ($220 / household, adapted from	60 m3/ household/ year	All new households	1

Code	Demand Management options	Costs included	Water savings	Participants	Scenario no.
		Willetts et al. 2010). Program management & advertising.			
S7	Local wastewater reuse & nutrient recovery for new housing developments	Net cost for decentralized sewer system with urine collection & localized recycling treatment ($320 / household, adapted from Willetts et al. 2010). Program management & advertising.	60 m3/ household/ year	All new households	2

Note: The costs for different types of desalination plants and wastewater recycling plants were estimated using a range of sources, including ENP Newswire, 2010; Times of Oman, 2010; Water-technology.net, 2011; Cote et al., 2005; Pearce, 2010.

7 MODEL RESULTS

The results from modeling the water savings and costs of each option are shown in Table 3 below. The demand management options tended to be the most cost-effective. Options DM7 and DM8 stand out for their cost-effectiveness and high potential in terms of water savings. The collective impact of these options and implementation issues are discussed in more detail in the following sections. Seawater desalination was found to be the least cost-effective of the 16 options modeled. At $ 1.15 /m^3 it costs almost double the second most expensive option, which was agricultural drainage desalination at $ 0.63 /m^3.

Table 3 Results from modeling water savings and costs of demand management and supply options

Code	Options	Present Value (million $)	Water saved or supplied in 2037 (Mm3/a)	Unit cost (PV$/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	Desalination for coastal resorts	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
S7	Local wastewater reuse & nutrient recovery	82.4	37	0.58

SCENARIO 1

The results from the water savings modeling for scenario 1 are shown in the graph in Figure 8. The top line of the graph shows the projected water demand to 2037, and each coloured band represents the water savings that could be achieved with each option, together this graph illustrates the cumulative water savings that can be achieved. The portfolio of options combined in scenario 1 would provide sufficient water savings to close the supply-demand gap in 2037. This would mean that the allocation of water from the Nile could officially remain the same as in 2011, except for agricultural efficiency offsets, which would be gained through water company sponsored efficiency in surrounding agricultural areas.

The key difference between scenario 1 and scenario 2 is that, for scenario 1 seawater desalination is used to supply water to coastal resorts, and wastewater is recycled for industrial areas. Total water savings of 541 million m3/year are projected for 2037 with scenario 1.

SCENARIO 2

The graph in Figure 9 displays the results from the water savings modeling for scenario 2. The combination of options in scenario 2 would also provide sufficient water savings to close the supply-demand gap in 2037. Total water savings of 529 million m3/year are projected for 2037 with scenario 2.

The key point of difference in scenario 2 is that the desalination of brackish agricultural water is undertaken to supply non-potable water to coastal resorts and industrial areas.

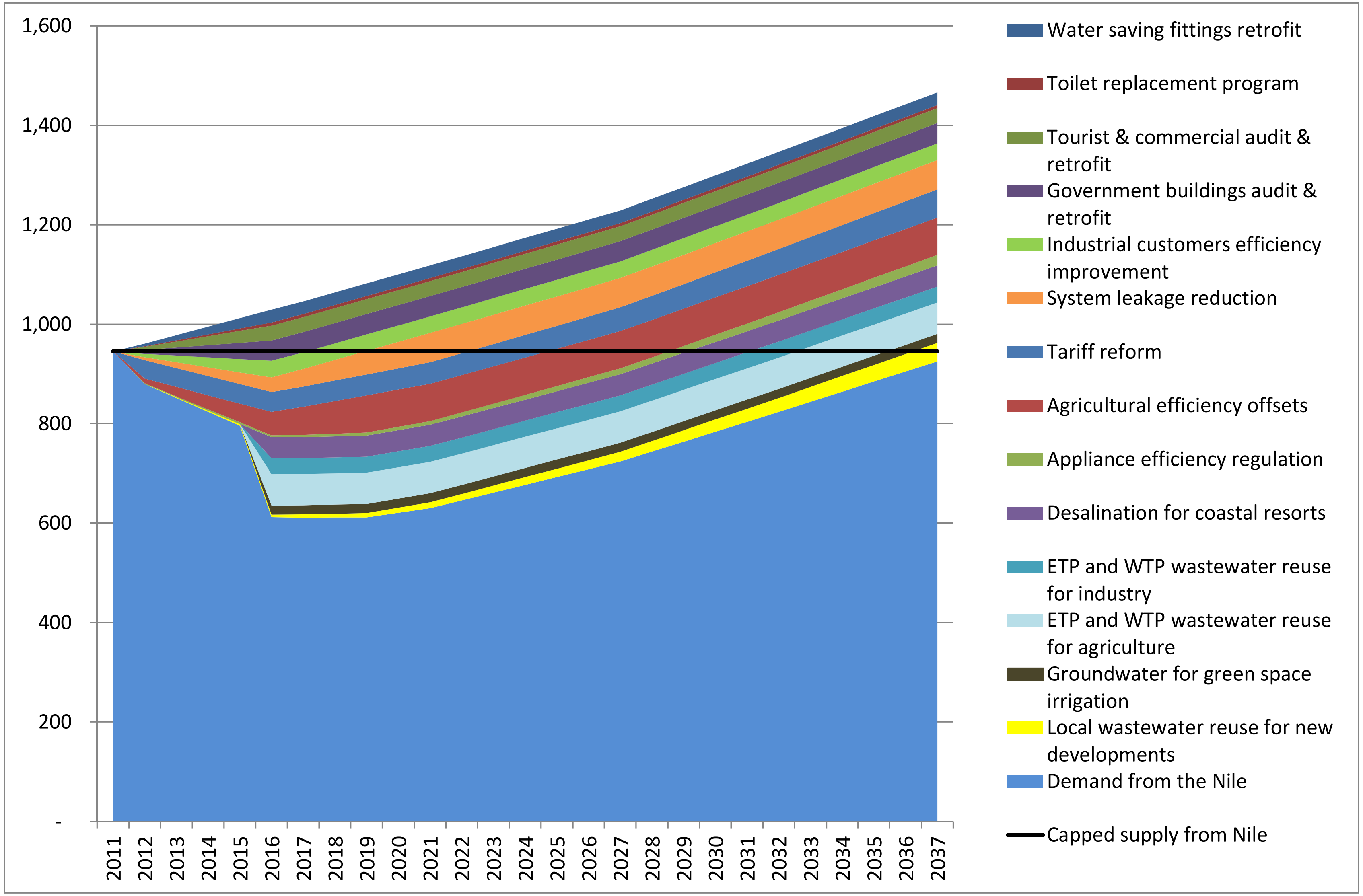


Figure 8 Projected water demand in Alexandria to 2037 with water savings from a portfolio of demand management and supply options – Scenario 1

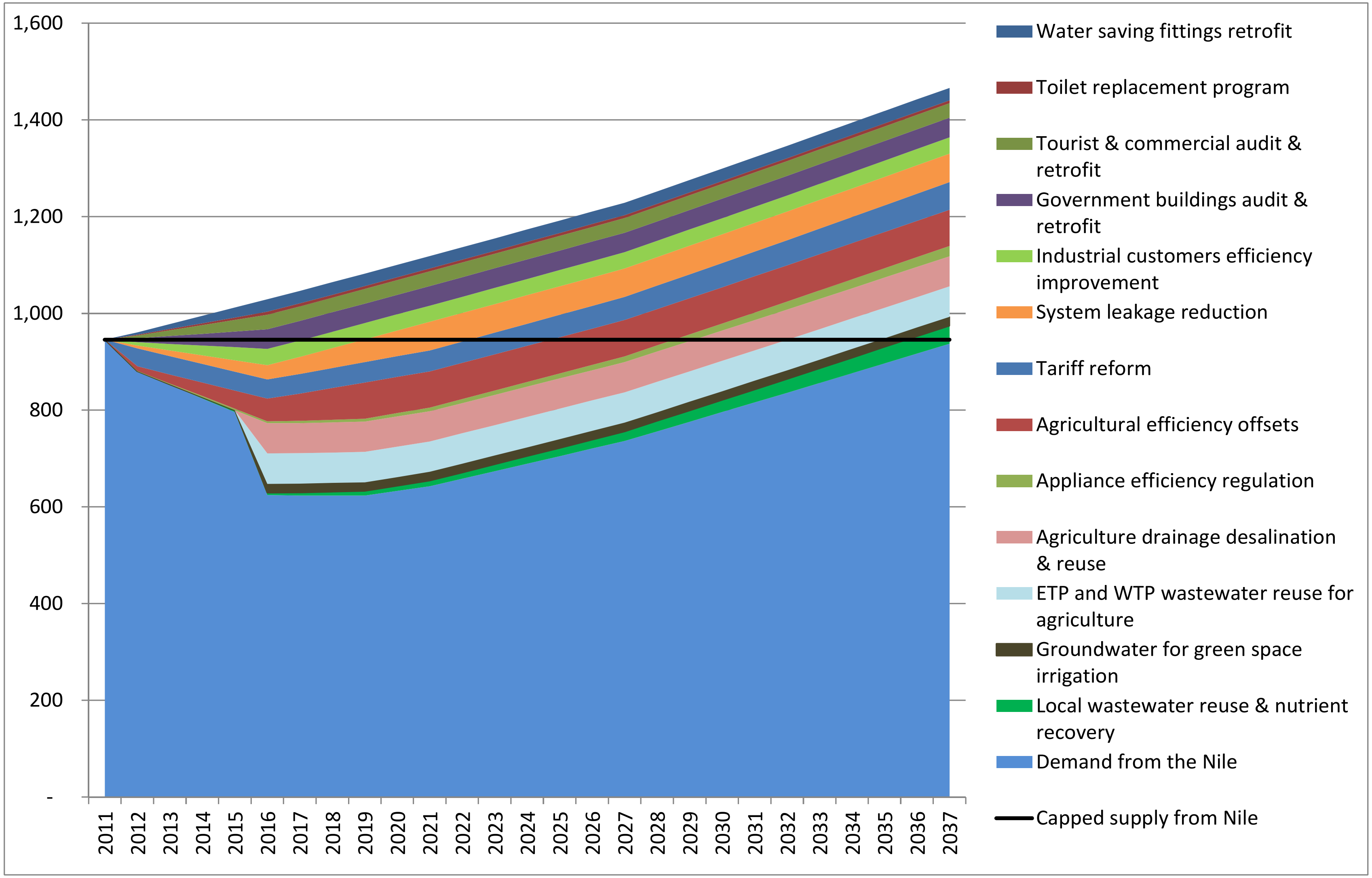


Figure 9 Projected water demand in Alexandria to 2037 with water savings from a portfolio of demand management and supply options – Scenario 2

8 BUSINESS CASE FOR OPTIONS – COSTING ANALYSIS

In this section, the results from the cost effectiveness analysis are illustrated to show the relative water savings and costs for each option.

SCENARIO 1

The cost curve shown in Figure 10 shows the sequence of options stepping up from the most cost-effective in the bottom left hand corner, up to the most expensive in the top right hand corner. The horizontal axis shows the cumulative water savings achieved with each successive program, while the vertical axis shows the absolute (not cumulative) unit cost for each option in terms of US dollars per cubic metre (m^3) of water saved. This graph sets out the sequence of programs that should be implemented for the most cost-effective water savings. It is clear from this graph that tariff reform (DM7) and agricultural efficiency offsets (DM8), provide large savings at low cost. The cost of options in this scenario range from \$0 /m^3 to \$1.15 /m^3.

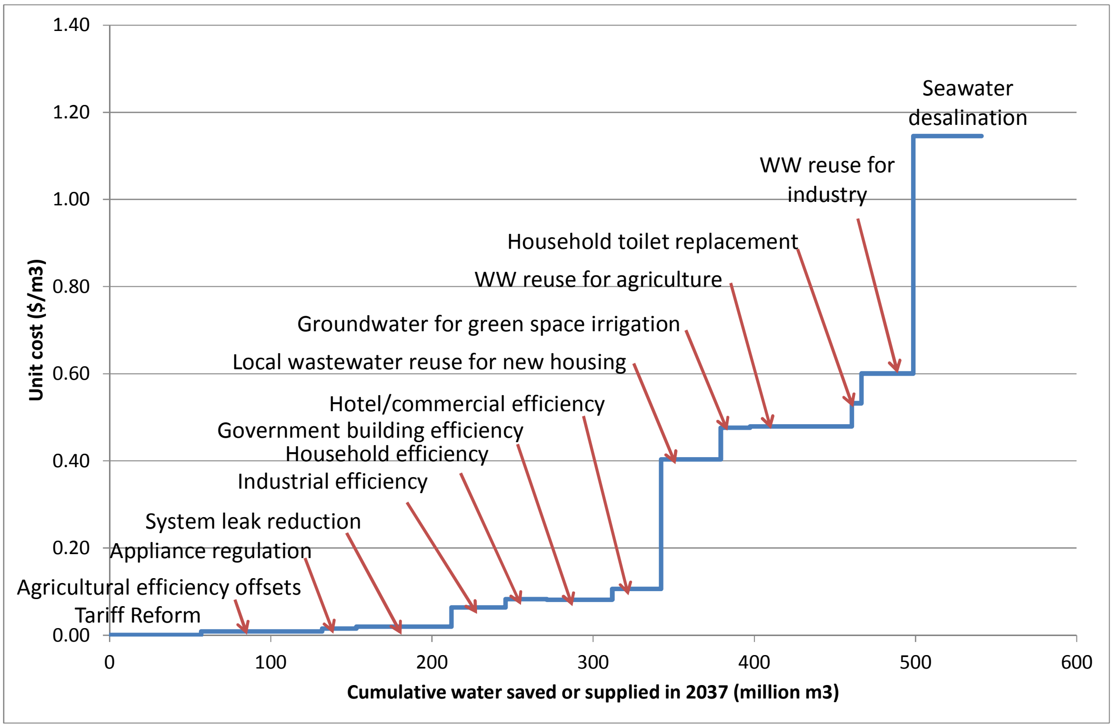


Figure 10 Supply curve for options in scenario 1

SCENARIO 2

The cost curve in Figure 11 shows the cumulative water savings and unit costs for the portfolio of options in scenario 2. This scenario achieves similar savings to scenario 1 and closes the supply demand gap, however the unit costs to achieve the savings are lower. Note that the most expensive option in this scenario is the agricultural drain desalination at \$0.63 / m^3.

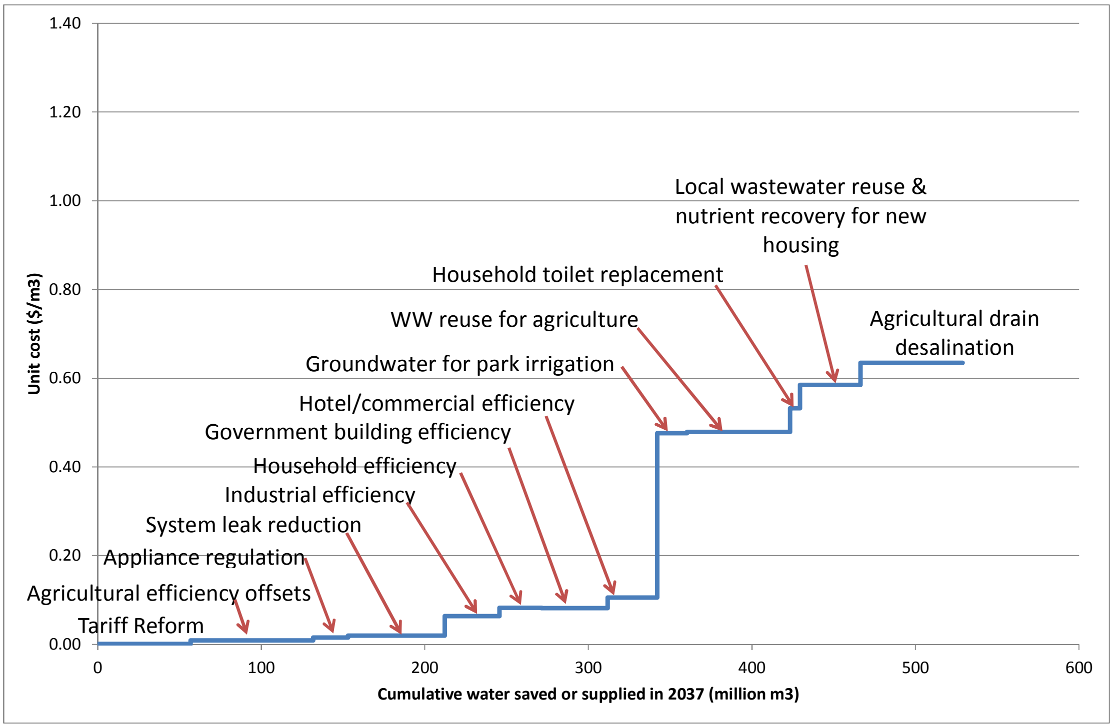


Figure 11 Supply curve for options in scenario 2

9 ACTION PLAN FOR THE FUTURE

This study shows that the extraction of water from the Nile system for the region of Alexandria can be capped at current levels, despite population growth, through to 2037. This can be achieved with a portfolio of options including water efficiency (demand management) and supply options. In the short term, the water efficiency options alone could have the effect t of decreasing total extractions from the Nile by over 20%.

The results of this study show that the most cost effective options are those that improve the efficiency of water use in Alexandria, that is, the demand management options, including agricultural efficiency offsets. Many of these water efficiency options have a lower unit cost than the *current operating cost of supplying water in Alexandria*. This means that there would be a significant net financial benefit to AWCO, and to the customers of AWCO, if these low unit cost options were implemented.

Furthermore, the demand reduction levels estimated for these options are not the maximum possible. The estimates of overall savings are likely to be conservative, and further analysis would be likely to increase the estimates of participant take-up and savings.

The implementation of the water saving options also has the effect of significantly reducing energy consumption, and therefore reducing greenhouse gas emissions, as described in Retamal et al. (2010). In addition, there is a significant opportunity for local economic development, in terms of the additional employment that would be generated in the

implementation of these options, and also the potential for local manufacture of water saving fittings and fixtures.

RECOMMENDATIONS

The authors make the following recommendations based on the results of this study.

1. That this analysis and results be used as a business case for significant investment in the water efficiency (demand management) options identified here, funded directly by AWCO, the Egypt Holding Company and supplemented by multi-lateral finance agencies.
2. That the results be shared with other water utilities and water resource agencies in Egypt, with a view to identifying opportunities to share resources and expertise in the design and implementation of options.
3. That further analysis of the potential for agricultural water use efficiency and offsets, and the implementation pathways for this option be investigated.
4. That discussions at the national level be expedited to ensure the implementation of a national scheme of water efficiency labelling and standards for appliances and fixtures, including toilets, showers, taps, washing machines, dishwashers, cooling towers, urinals and irrigation equipment.
5. That pricing reform be considered including raising water prices in line with the recommendations of the Chemonics report, in association with a program of household water efficiency investment targeted at low socio-economic areas as a compensation.
6. That a best practice program of leak detection and repair, and pressure management be implemented as soon as possible.
7. That new regulations be developed by AWCO in collaboration with the Governorate, to require new housing, commercial and industrial developments and buildings, including major refurbishments, to incorporate best-practice water efficiency and localised reuse of wastewater as a condition of connection to the water supply and sewerage system.

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