INTEGRATED RESOURCE PLANNING FOR ALEXANDRIA, EGYPT

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ABSTRACT

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.

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 been undertaking research on the urban water supply-demand balance in Alexandria, the second largest city in Egypt. Initial analysis on water demand and potential water demand management, wastewater reuse and new supply options for the city of Alexandria was undertaken by the Institute for Sustainable Futures (ISF), University of Technology, Sydney, and the Centre for Environment & Development for the Arab Region & Europe (CEDARE) as part of the SWITCH Water Demand Management Training and through a subsequent research project. The results have relied on limited data and information regarding water use, but included a survey of household water use designed by the authors and undertaken by the Alexandria Water Company. This was coupled with the extensive local knowledge of training participants from subsidiary companies of the Egyptian Holding Company for Water & Wastewater, and the experience of ISF staff in such research in the Middle East.

This paper aims to provide insight into the application of the Integrated Resource Planning process in an emerging economy city in a water-constrained region, and the relative merits of different options for maintaining the supply-demand balance.

Background

The allocation of the Nile River resources to Egypt is based on a 1959 agreement with Sudan that allocates 55 billion m^3) to Egypt. This is supplemented by very small volumes of water from other sources. The majority of water is used in agriculture. 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.

The Integrated Resource Planning process

Integrated resource planning (IRP) has its origins in the electricity industry in the 1980's, with a recognition that it is often cheaper and quicker to reduce the demand for electricity than 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 agency 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).

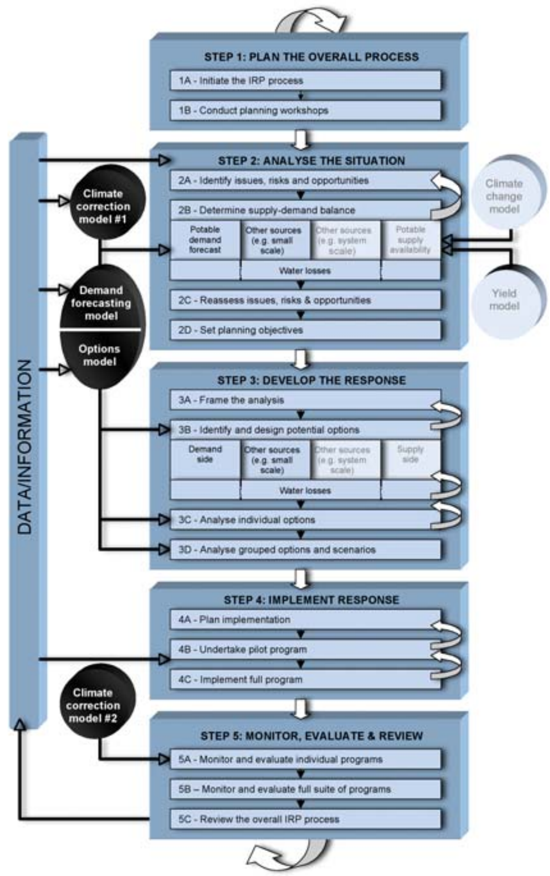

Figure 1: The integrated resource planning process (Turner et al. 2006).

Methodology

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 planning. 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 were conducted 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. These culminated in the development of an integrated urban water management plan (see AbuZeid et al. 2009, 2010a, 2010b; Chemonics Egypt, 2010; Yassin, 2010). 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 workshops, 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 to reduce the volume of water extracted from the Nile system.

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 unit costs.

Description of Options

A range of both demand management and supply options were developed to suit the Alexandria city context. The city sits on the coast at the edge of the Nile Delta and features the Maryut lake system in addition to several canals, some of which supply water to the city from the Nile, while others provide drainage for agricultural areas. Other important features of Alexandria that influenced the selection of options are the large industrial and port areas and the significant stretches of coastal tourist resorts. The options that were analysed have been summarised in the following table.

Table 1: Summary of options

Code	Options
DM1	Household water saving fittings retrofit
DM2	Toilet replacement program for households
DM3	Tourist & commercial buildings audit & retrofit
DM4	Government buildings audit & retrofit
DM5	Industrial facilities audit & retrofit
DM6	System leakage reduction
DM7	Tariff reform
DM8	Agricultural efficiency offsets (to increase supply to the city)
DM9	Appliance efficiency regulation (at the national level)
S1	Desalination for coastal resorts
S2	Wastewater reuse for industrial properties
S3	Agricultural drainage water desalination & reuse for industries & coastal resorts (non-potable use)
S4	Wastewater reuse for agriculture
S5	Groundwater for urban green space irrigation
S6	Local wastewater reuse for new

	developments (incorporating decentralised sewer systems)
S7	Local wastewater reuse & nutrient recovery (incorporating decentralised sewer systems & urine diversion)

The demand-side options range from conducting retrofits at both residential and non-residential properties, to tariff reform, fixing leaks in the network, to the regulation of efficient appliances. Also included in the demand side options is the concept of improving irrigation efficiency in agricultural areas in order to provide more water to the city. The supply side options include seawater desalination for potable use, wastewater recycling for non-potable uses, agricultural drainage water desalination for non-potable uses, local use of groundwater and wastewater recycling for non-potable use in new housing areas. This final option has been split into two (options S6 and S7) as the local collection and recycling of wastewater allows for different servicing arrangements. In addition to wastewater recycling and reuse, other resources can be recovered, such as nitrogen and phosphorous in urine which can be sold as fertiliser.

Some of these options would essentially supply water to the same demands (e.g. S6 and S7), so in order to develop a comprehensive portfolio of options for the city to undertake, two slightly different scenarios that eliminate overlap were developed, to address the supply gap that will arise in 2037. The results are shown in the following section.

Results

The first step in the project was to analyse the results of the household end use study undertaken by the Alexandria Water Company (AWCO). These results were used to improve the accuracy of the preliminary end use data that was collated during the training workshop in 2008. The result is a breakdown of household water end uses as shown in Figure 2. These figures were used to assist in calculating expected savings for demand management options.

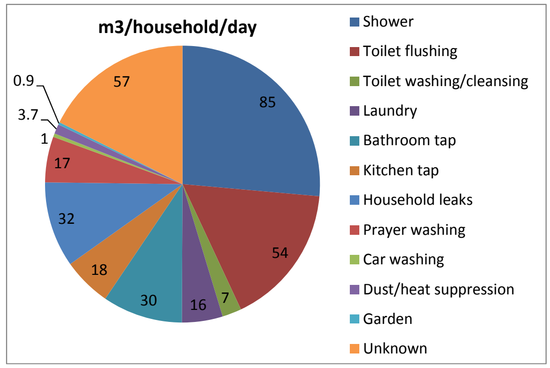

Figure 2: Breakdown of household end use in Alexandria, Egypt (source: training workshop in 2008-09 and AWCO 2010 household survey)

Secondly, the water savings (or water supplied) from the supply and demand management options were modelled and the capital and operating cost were estimated for each of the options, based on the best available data. These costs were used to calculate a unit cost for each option, based on a discount rate of 7% over a 30 year timeframe for all options.

The results of scenario 1 are shown in Figure 3. The graph illustrates that by implementing the portfolio of both demand and supply options, the city can maintain its extractions from the Nile at the same capped level until 2037. The graph also shows that with the implementation of demand management initiatives alone, the city can meet its demands until 2028 before additional supply or demand measures need to be undertaken.

The key difference with scenario 1 is that seawater desalination is used, whereas in scenario 2, agricultural drainage water desalination is used instead. Other differences can be observed from the legends in Figures 3 and 5.

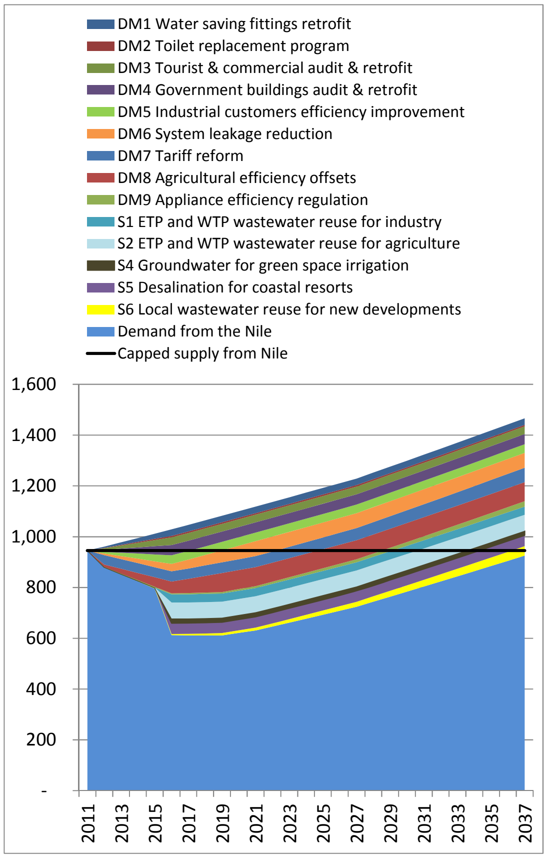

Figure 3: Scenario 1 water supply-demand balance for Alexandria

The results from costing the suite of demand management and supply options in scenario 1 are shown in terms of levelised unit costs in Figure 3. This curve 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 figure 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 most expensive option in this scenario is seawater desalination which has an expected unit cost of $1.15 /$m^3$.

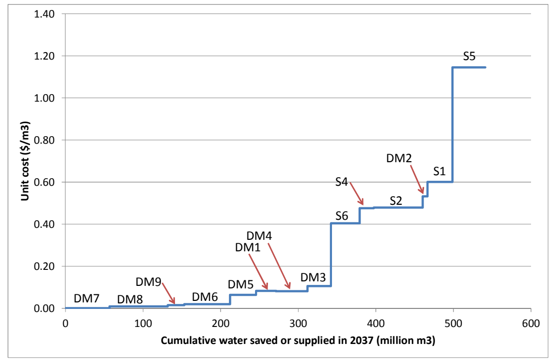

Figure 4: Scenario 1 supply curve for Alexandria

The complete set of results for options in both scenario 1 and 2 are set out in Table 2 below, including both water savings and unit costs.

Table 2: Water savings and unit costs calculated for each demand or supply option in the study

Code	Water saved or supplied in 2037 (Mm3/a)	Unit cost (PV$/PVm3)
DM1	26	0.08
DM2	6	0.53
DM3	30	0.11
DM4	41	0.08
DM5	34	0.06
DM6	59	0.02
DM7	57	0.00
DM8	75	0.01
DM9	21	0.02
S1	42	1.15
S2	32	0.60
S3	62	0.63
S4	63	0.48
S5	18	0.48
S6	37	0.40
S7	37	0.58

The water supply-demand balance results from scenario 2 are shown in Figure 5. This combination of options also allows the city to maintain its extractions from the Nile at the same capped amount. However, the different supply sources would enable the city to achieve the same water balance more cost-effectively, as can be seen in the supply curve for scenario 2 in Figure 6. While many of the options in scenario 1 and 2 are the same, the supply options differ and the use of desalination agricultural drainage water appears much more cost effective than seawater desalination, as it was calculated at only \$0.63 /m^3.

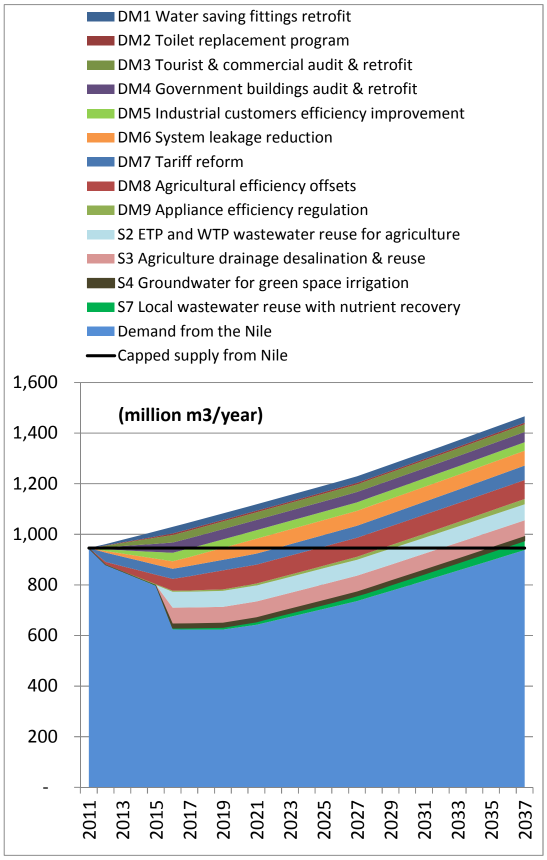

Figure 5: Scenario 2 water supply-demand balance for Alexandria

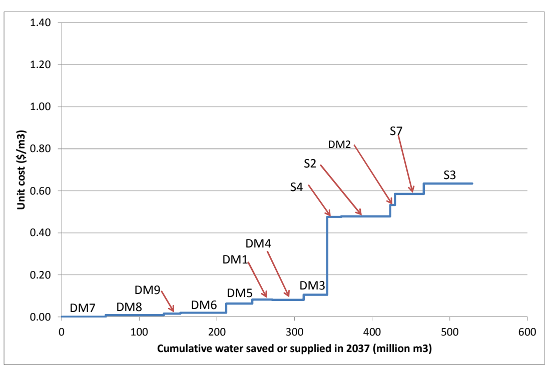

Figure 6: Scenario 2 supply curve for Alexandria

Discussion

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 of decreasing total extractions from the Nile by over 20%.

The results 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.

Conclusion

The water efficiency (demand management) options identified here are highly cost-effective, and could be funded directly by AWCO, by the Egypt Holding Company for Water and Wastewater and supplemented by multilateral finance agencies, with net benefits to AWCO. In terms of further application, these results are likely to be applicable for other water utilities and water resource agencies in Egypt.

There is a clear hierarchy of cost-effectiveness of options, starting with pricing reform and regulation, followed by water efficiency options including structural changes in both urban and agricultural water using equipment, appliances, reticulation systems and practices. The wastewater reuse and supply options have a relatively higher unit cost.

The implementation of some options will require changes in institutional and governance arrangements, including actions that span across all tiers of government.

The results lead to several key conclusions in relation to implementation:

1. There is a need for further analysis of the potential for agricultural water use efficiency and offsets.

2. 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 would have significant advantages in terms of a low cost efficiency improvements and protecting an investment in retrofitting of efficient fixtures.

3. Pricing reform should be considered in association with a program of household water efficiency investment targeted at low socio-economic areas as compensation.

4. A best practice program of leak detection and repair, and pressure management should be implemented.

5. In order to implement the options for new houses, buildings and developments, it will be necessary to develop new regulations, including by AWCO in collaboration with the Governorate. These regulations would 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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References

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, March 2010.

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

Chemonics Egypt, 2010, Affordability Assessment to Support the Integrated Urban Water Management in Alexandria – Draft, 16 October 2010.

Retamal, M.L., Turner, A.J. & White, S. 2010, The water-energy-climate nexus: systems thinking and virtuous circles, in Howe, C., Smith, J. and Henderson, J. (eds), Climate Change And Water: International Perspectives on Mitigation and Adaptation, American Water Works Association and IWA Publishing, Denver, USA and London, UK, pp. 99-109.

Turner, A.J., Willetts, J.R. & White, S. 2006, The International Demand Management Framework Stage 1, [prepared for Canal de Isabel II], Institute for Sustainable Futures, UTS, Sydney. http://www.isf.uts.edu.au/publications/turner etal2006idmf.pdf

Turner, A.J., Willetts, J.R., Fane, S.A., Giurco, D., Kazaglis, A. & White, S. 2008, Guide to Demand Management, [prepared for Water Services Association of Australia], Institute for Sustainable Futures, UTS, Sydney