Strategic Planning for Water Security in Developing Countries

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ABSTRACT: Water security is an increasing problem in many areas of the world, exacerbated by population growth, economic development and climate change. Infrastructure such as reservoirs may be used to increase water security, and this requires planning over an extended period for approval and construction before new infrastructure can be operational. Long term planning is sensitive however to uncertainty about the future, including for example on local impacts of climate change. This paper proposes a strategic planning approach to water security with a 15 – 40 years' time horizon, consideration of various scenarios and a focus on "no-regrets" actions which would strengthen resilience and bring benefits in all scenarios. Examples of these are actions to reduce water losses and to manage demand for water. The paper draws on research conducted for the EU SWITCH project in the city of Alexandria, Egypt, and on other studies in south and south-east Asia.

1 INTRODUCTION

Water security has become recognised as a useful concept in water resources assessment. Grey and Sadoff (2007) defined it as: "the reliable availability of an acceptable quantity and quality of water for health, livelihoods and production, coupled with an acceptable level of water-related risks."

It may be deduced from this definition that water security depends on:

- The timing and quantity of rainfall and river flows and the availability of groundwater
- Variability in the timing and quantity of rainfall, river flow and groundwater
- The quality of the surface and groundwater, depending on pollution / treatment of domestic, industrial and agricultural wastes etc.
- The demand for water for various uses, which in itself depends on population, economic development, diet, lifestyles etc.
- The vulnerability of each type of water use to changes in water quantity and quality.

The steady increase in demand caused by population growth and economic development has reduced water security in many areas and increased the risks from the natural variability of supply. Furthermore, pollution and changes in land use and climate pose additional risks to the quantity and quality of water resources and threaten water security.

Although climate change has a high profile, it is important to note that in the short term these other factors generally have a greater impact on water security, especially in Africa and Asia.

Climate variability is already a major issue, with floods and droughts causing huge damage to national economies. In Ethiopia for example "a single drought event within a 12-year period (the historical average is every 3-5 years) will diminish average growth rates across the entire 12-year period by 10%" according to a World Bank study (Sadoff and Muller 2009). Climate change will exacerbate this variability and the frequency of extreme floods and droughts.

Indeed the Intergovernmental Panel on Climate Change (IPCC) has concluded that "In many locations, water management cannot satisfactorily cope even with current climate variability, so that large flood and drought damages occur. As a first step, improved incorporation of information about current climate variability into water-related management would assist adaptation to longer-term climate change impacts." (Bates et al 2008, p3).

The effects of this variability can be reduced by storing water from wet periods to use in dry periods, and therefore storage is a means of increasing water security. It may be necessary to store water from wet seasons to dry seasons (to manage high seasonal or "intra-annual" rainfall variability) and from wet years to dry years ("inter-annual" variability). Both intra-annual and inter-annual variability tends to be higher in the tropics and sub-tropics, with a cycle of wet and dry seasons and the influence of major climatic phenomena such as the annual monsoon and the periodic El Nino.

Reservoirs are the major form of storage and Table 1 gives an overview of average storage in large reservoirs in different regions of the world, together with data on the average water resource and water use per person. The averages conceal variations within the regions, for example between dry areas and wet areas, and between countries with substantial development of large reservoirs and those with hardly any. Nevertheless it is clear from the final two columns of the table that the developing regions of Asia and Sub-Saharan Africa have lower reservoir storage volumes than the richer regions of North America, Oceana and Europe. This is despite the generally higher rainfall variability in the tropics and sub-tropics. In some locations however the topography may not be suitable for reservoir storage, river flood plains for example. Groundwater development may be an important option in these areas, such as Bangladesh.

Table 1 Water resources and reservoir storage by region

Region	Actual Renewable Water [ARWR] per person (m^3/yr)	Water usage [WU] per person (m^3/yr)	WU/ARWR (%)	Total reservoir storage (km^3)	Total reservoir storage as % of annual ARWR	Total reservoir storage per person (m^3)
Asia	3938	581	15	1299	9	353
Europe	10663	566	5	1199	48	1647
Middle East and North Africa	1408	782	56	285	62	867
Sub-Saharan Africa	6944	152	2	580	11	741
North America	17770	991	6	1922	32	5737
Central America and Caribbean	6956	561	8	150	12	833
South America	45323	437	1	969	6	2563
Oceana	52906	812	2	111	7	3469
WORLD	8281	555	7	6616	12	1008

Source: Adapted from White (2010)

2 VULNERABILITY AND RESILIENCE

Research on adaptation to climate change has included investigating the vulnerability and resilience of infrastructure, processes and activities, defining these as follows (Bates et al, 2008):

"Vulnerability: Vulnerability is the degree to which a system is susceptible to, and unable to cope with, adverse effects of climate change, including climate variability and extremes. Vulnerability is a function of the character, magnitude, and rate of climate change and variation to which a system is exposed, its sensitivity, and its adaptive capacity."

"Resilience: The ability of a social or ecological system to absorb disturbances while retaining the same basic structure and ways of functioning, the capacity for self-organisation, and the capacity to adapt to stress and change."

These definitions are related to climate change, but the concepts may be used for assessment of other risks to water security. Table 2 illustrates their use in a study by WHO/DFID (2010) into the effect of climate change on water supply and sanitation. The analysis focused on three climate change scenarios which were identified as particularly important for water supply and sanitation: increased rainfall, decreased rainfall and increased rainfall intensity. Table 2 summarises the degree of vulnerability of improved water supply facilities to these changes in rainfall, and identifies their resilience. This example focuses on technologies, but technical factors should not be considered in isolation - vulnerability and resilience also apply to institutions, and to communities and households.

Table 2: Levels of vulnerability and resilience of improved water-supply facilities under different climate scenarios

	Utility managed piped water	Community managed piped water	Protected wells (deep)	Protected wells (shallow)	Protected springs	Rainwater collection
			Environmental vulnerability			
Increased rainfall	++	+++	+	+++	++	+
Decreased rainfall	++	+++	+	+++	+++	+++
Increased intensity	++	+++	+	+++	+++	++
			Resilience			
Increased rainfall	♦♦♦	♦♦	♦♦♦	♦	♦♦	♦♦♦
Decreased rainfall	♦♦♦	♦	♦♦	♦	♦	♦
Increased intensity	♦♦♦	♦	♦♦	♦	♦	♦♦

Vulnerability ratings range from least vulnerable (+) to most vulnerable (+++); resilience ratings range from least resilient (♦) to most resilient (♦♦♦).
Source: WHO/DFID (2010)

3 STRATEGIC PLANNING IN THE WATER SECTOR

Strategic planning is a well-established activity in business and government comprising planning to achieve a desired end. This involves deciding on an end point or Vision to be achieved and identifying appropriate means to get there, and the necessary resources. In the water sector, both the lifespan of existing water infrastructure and the period for planning and installing new infrastructure are long, hence a time horizon of 15 – 40 years may be needed for strategic planning. There are many uncertainties however about the long term situation in any area and difficulty in predicting the population, demand for water and pollution within the area, and also in predicting the global levels of global greenhouse gas emissions and in downscaling to predict the resulting impact on the local climate and water resources. These uncertainties can be incorporated into planning by considering several Scenarios. A Scenario is a plausible and internally-consistent description of a possible future situation, a story about the way an area or domain of interest might turn out at some specified time in the future.

The threats to water security and the difficulties of predicting over a long timescale require a flexible and adaptive approach. This may include actions which address short term requirements and which satisfy a “no-regrets” or “low-regrets” criterion, so that the actions are also appropriate in the long term, under a range of Scenarios. Such short-term actions need to be consistent with long-term strategic options and provide some flexibility, so that they may be modified to achieve the Vision under the various Scenarios.

SWITCH (2006-2011) brought together 33 partners from 15 countries around the world in an EU-funded research project which considered water supply, wastewater and stormwater together in planning for a sustainable city of the future. SWITCH followed a participative process with stakeholders in cities in four continents, to develop strategic plans for their city. Although developed for a city, this strategic planning process could also be applied to other geographical areas.

4 CASE STUDY ON STRATEGIC PLANNING AND WATER SUPPLY OPTIONS IN ALEXANDRIA (EGYPT)

Key steps in the SWITCH strategic planning process are listed below (adapted from Howe et al 2011)

1. Agree on a Vision for a sustainable Urban Water System (say in 2037)
2. Define sustainability objectives and a set of sustainability indicators
3. Generate Scenarios of how the city may be in 2037 (including the business-as-usual scenario) - for examples, see the Alexandria case in Box 1
4. Generate possible urban water management strategies for achieving the Vision in the context of the different Scenarios
5. Refine the strategies into Options
6. Investigate the Options, collecting necessary data and analysing the Options with projections to 2037, using models for the various Scenarios and assessing sustainability according to the indicators
7. Compare strategy Options and select which Options to adopt
8. Implementation of Options
9. Monitoring, feedback and adjustment of strategies and Options

Box 1 Vision and Scenarios developed by the Alexandria Learning Alliance for 2037

Stakeholders in Alexandria developed a Vision and three Scenarios in workshops as follows:

Vision
'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..'

Worst case scenario
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 increased national water demand and/or climate change)*
- *increased risk of flooding (due to sea level rise)*
- *Poor availability of financial resources.*

Best case scenario
In 2037, Alexandria is a city which:
- *Has a population which has largely stabilized (at 8 million)*
- *Is benefiting from a dynamic and fast growing economy*
- *Has a guaranteed allocation of Nile water similar to that of 2007*
- *Has a positive scenario related to climate change (with sea level rise minimum and increased rainfall)*
- *Benefits from the new vitality of the Egyptian economy which means that financial resources are readily available.*

Business as usual
In 2037, Alexandria continues to be a city dealing with considerable uncertainty:
- *Population is 10 million, and continues to grow.*
- *National allocation of Nile water is 20% less than in 2007*
- *Economic growth has been steady but unspectacular*
- *Rising sea levels are starting to threaten some parts of the city.*

Source: Howe et al (2011)

Strategic planning workshops for water supply in Alexandria under the SWITCH project then identified and analysed nine demand management Options and seven supply Options as listed in Table 3.

Table 3 Demand and Supply Options modelled for Alexandria

Code	Option
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)

Source: Retamal and White 2011, White et al. 2011

The options were analysed to determine how much water they could save or supply in 2037, and the unit cost of the water saved or supplied (calculated as the present value of the costs and the volume of water). It was estimated that more than 300 million m^3 could be saved per year by demand management measures costing less than a quarter of the price of the cheapest supply option. These results are illustrated in the supply curve shown in Figure 1, assuming that the least cost options are implemented first.

5 BUILDING RESILIENCE OF WATER UTILITIES IN ASIA

Demand management options are examples of "no regrets" actions, which bring benefits across a wide range of scenarios. The value of demand management options is increasingly recognised, for example a rapid assessment of 14 water service providers in the Asia region and Australia (USAID and WaterLinks, 2012) considered their capacity to build resilience against climate change impacts. Interestingly, all the water service providers reported having prepared or taken actions that contribute to building their adaptive capacities through the "no regrets" approach, with the two most common actions being reducing water losses (physical and commercial leakages) and reducing consumption and / or managing demand.

One of the most cost-effective options in Alexandria was identified as System Leakage Reductions (DM6). Leakage is a major component of Non Revenue Water (NRW) and Table 4 indicates the potential water savings by reducing water losses and the scope for service improvements found in another study of nine urban water utilities in Asia (Asian Development Bank 2010).

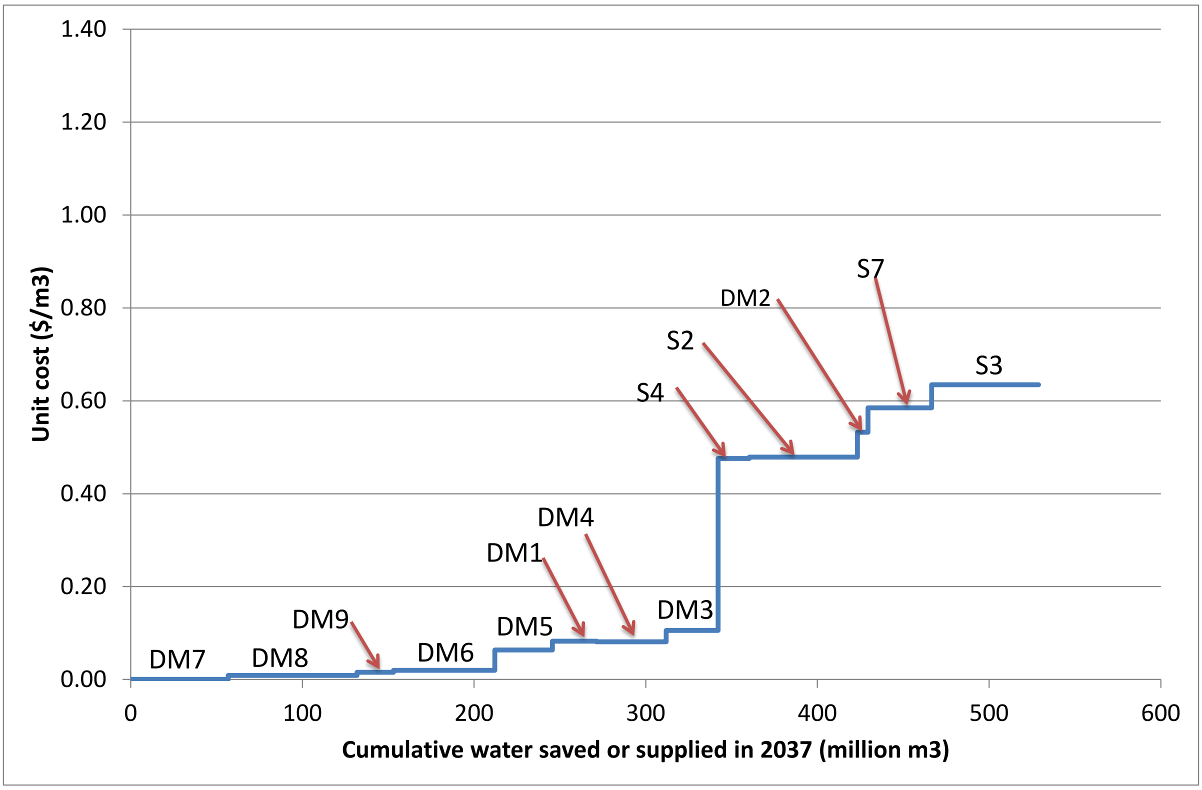

Figure 1 Supply Curve for Alexandria (Source: Retamal and White 2011, White et al. 2011)

Table 4. Coverage and Non Revenue Water in Nine Asian Utilities

City / Utility	Year	Piped coverage (% of population)	Average availability (supply hours)	NRW (% of total supply)
Bangkok	2008	99%	24	30.2%
Colombo	2008	92%	24	35.7%
Jamshedpur	2009	81%	7	9.9%
Kuala Lumpur	2008	100%	24	33.2%
Phnom Penh	2008	91%	24	6.2%*
Shenzhen	2008	100%	24	13.5%
Singapore	2008	100%	24	4.4%*
Manila – Manila Water	2008	93%	24	19.6%
Manila – Maynilad	2008	72%	18	63.8%

*The data for Phnom Penh and Singapore are Unaccounted for Water

Source: Asian Development Bank (2010).

6 CONCLUSIONS

Water security is a problem in many areas, particularly in developing countries with relatively low reservoir storage and high rates of population growth, economic development and climate variability. Proposed measures for adaptation to climate change may also have application to broader water security issues in the short term, by reducing vulnerability and building adaptive capacity and resilience. A range of scenarios can be considered in strategic planning to take account of uncertainties about future conditions and to enable evaluation of different options. Planning should also allow for the possible need to revise plans to take account of changing circumstances or projections. No regrets actions include demand management and water loss reduction options, which may be cheaper and quicker to implement than large –scale infrastructure developments, and may delay the time when these developments are necessary. Water service providers in Asia and elsewhere are adopting water demand management and water loss reduction options to improve services and build resilience.

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