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Water Demand Management: A Key Building Block for Integrated Resource Planning for the City of the Future

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Abstract

The looming water scarcity in the world, coupled with increasing environmental degradation has brought into focus the need to change the way water resources are managed. The objective of SWITCH Project is to trigger a paradigm shift in urban water management and promote a strategic and integrated planning approach for achievement of sustainable urban water management. This paper briefly describes the activities that have so far been done under the SWITCH Project Work Package dealing with Water Demand Management (WDM). The paper presents findings of an initial literature review that identifies WDM as one of the key building blocks of Integrated Resource Planning, highlights commonly used WDM tools, and presents current international developments in the area of WDM. Additionally, initial findings of a scoping study in the SWITCH project demonstration city of Zaragoza are presented. Finally, the paper briefly sets out plans for future activities under the WDM Work Package.

Keywords: integrated resource planning, water demand management

1 Introduction

It is becoming clearer, even to non-members of the scientific community that the rapidly increasing global population and urbanisation, coupled with the impacts of climatic change are major contributors to the looming water scarcity. Water scarcity is acknowledged to be a key barrier to attainment of MDGs in low-income countries. Currently, about 30 countries are considered to be water stressed, of which 20 are absolutely water scarce (Seckler, Molden and Barker, 1998). It is projected that by 2050, about one-third of the population in the developing world will face severe shortage (ibid). The water scarcity situation will get worse in the world's urban areas where it is projected that over 50% of the world's population will live by 2015 (United Nations, 2004).

The alarming rate of water scarcity, coupled with widespread environmental degradation has brought into focus the need for planned action to manage water resources in a more effective way. The dwindling water resources need to be optimally managed while minimising the negative impact on the environment.

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The SWITCH project was conceived arising out of a realisation that continued application of the conventional urban water management (UWM) concept to contemporary times will not deliver the required results. The main objective of the SWITCH project is "the development, application and demonstration of a range of tested scientific, technological and socio-economic solutions and approaches that contribute to the achievement of the sustainable and effective UWM schemes in 'The City of the future'" (SWITCH project Description of Work, 3rd February 2006). The SWITCH project is a multi-disciplinary integrated research project that aims at creating a paradigm shift in urban water management. This paper highlights key findings from a literature review carried out under the Work Package 3.1 on WDM, provides background information on the City of Zaragoza, where WDM-related action research will be conducted, and briefly highlights the way forward.

2 WDM: the basic concepts

Water demand management (WDM) may be defined as the development and implementation of strategies, policies, measures or other initiatives aimed at influencing demand, so as to achieve efficient and sustainable use of the scarce water resource (Savenije and van der Zaag, 2002). Demand management is any action that modifies the level and/or timing of demand for a particular resource (White and Fane, 2001). WDM contrasts with the conventional supply-driven approach to water resources management, whose response to the ever increasing water demand is development of new water sources. This is not sustainable, as the number of viable sources in any country is limited and has to satisfy competing demands in other sectors. Furthermore, the costs of development of new sources and treatment of raw water are increasing. Instead of always opting for development of new water resources to satisfy demand, the WDM approach aims at initially assessing the efficiency of water use both at the utility and consumers' levels.

2.1 WDM, a critical aspect of the Integrated Resource Planning Process

WDM is a key aspect of the Integrated Resource Planning (IRP) approach that was first adopted in the energy sector in the 1980s. IRP may be defined as a comprehensive form of planning that uses an open and participatory decision-making process to evaluate least-cost analyses of demand-side and supply side options (Beecher, 1995). IRP is a process in which water utilities determine the least cost options that they can use to provide their customers with water-related services that they demand rather than the water itself (Howe and White, 1999). The guiding philosophy for IRP is that demand for a resource such as water is not a demand for that resource itself but rather for the services that the resource provides, often called end uses. As such, consumers are perceived to generate demand for the end uses, such as clothes washing or toilet flushing, rather than a demand for litres of water (White and Fane, 2001). Therefore, one way to fulfil the demand could be increasing the efficiency of resource use, as it is assumed that providing the same services with less resources makes no difference to the consumer. IRP is a systematic planning process that identifies the most efficient means of achieving the goals, while considering the costs of the project impacts on other societal objectives and environmental management goals (Maddaus and Maddaus, 2001).

IRP is a long-term iterative process that involves a cycle of evaluating and assessing options, investing in selected options, assessing the conservation results and demand forecasts, and then re-evaluating options. The key steps in a model IRP process include (Maddaus & Maddaus, 2001):

- Preparation of a water demand forecast,
- Assessment of existing conservation programmes,
- Demand forecasts for normal, dry and wet and critical year conditions,
- Supply side planning to identify water sources with safe yields for all or part of future demand,

- Demand side planning to identify additional conservation methods to reduce demand, quantified in terms of costs and savings,
- Supply reliability evaluation, which compares the probability of a supply shortage with short term demand reductions that could be used to balance supply and demand during droughts,
- Resource strategies, that combine new supply development and demand reductions into a manageable number of options,
- How the utility goals/policies inform evaluation of supply reliability and resource strategies,
- Financial planning for funding the IRP projects. This could include tariff-setting for WDM,
- Public input throughout the project cycle, and
- Evaluation of the results, to keep the plan updated.

Table 1 shows the major differences between IRP with the traditional urban water planning. The table shows that shifting from a conventional urban water planning process to IRP requires a paradigm shift in the way urban water resources are managed.

Table 1: Comparison of traditional urban planning with IRP
(Adapted from Beecher, 2005; Maddaus and Maddaus, 2001)

Criteria	Conventional Planning	IRP
Resource Options	Supply options	Demand and supply options
Resource ownership and control	Utility-owned and centralised	Some resources owned by other utilities, other producers, customers
Planning process	Mainly departmental	Largely inter-disciplinary
Plan selection criteria	Minimise costs and maintain system reliability	Diverse criteria e.g. risk reduction, economic development, environmental quality
Role of public groups	Interveners	Participants
Supply reliability	Constraint and high priority	Decision variable
Environmental quality	Constraint, comply with regulations	Planning objective
Risk	Should be avoided	Should be managed

2.2 WDM measures commonly practised

As already stated at the beginning of Section 2, demand management measures aim to minimise either the overall or peak demand for water, by increasing the efficiency of water use. There are four major categories of WDM measures (White and Fane, 2001): those measures that (i) increase system efficiency at the utility level; (ii) physically increase end use efficiency; (iii) promote locally available resources not currently being used, such as rainwater harvesting; (iv) promote substitution of resource use, e.g. use of waterless sanitation; and (v) use economic instruments to bring about an improvement in resource usage, such as use of tariffs. Box 1 shows commonly applied measures

Box 1: WDM measures commonly applied

At Policy level

- o Policy framework to create enabling environment for the water utilities to adopt WDM
- o Approval of tariffs that promote water demand management
- o Approval of house plumbing bye-laws that encourage water demand management

At the utility level

- o Reduction in system losses, including leakage detection and repair
- o Operational changes, such as pressure reduction and reduced mains flushing or reservoir cleaning
- o Metering, pricing and billing reforms, e.g. use of universal metering, volume-based pricing
- o Disconnecting illegal connections and preventing new illegal connections
- o Control of overflowing water tanks
- o Ensuring that meters fitted in the system are relatively accurate
- o Imposing heavy penalties to illegal water users
- o Controlling or abolishing street water points
- o Institutional capacity building in the utility to raise the importance of WDM measures
- o Ensuring accountability of staff of the water utility
- o Introducing efficient and informative billing systems
- o Rationing water, when necessary
- o Detailed feedback systems for customers which provide information on water use.
- o Comprehensive information, education, training and advisory services to customers
- o Detailed water use analysis (audits) for water consumers in the various sectors
- o Minimum performance standards for efficiency of equipment and appliances
- o Financial incentives for purchase and installation of efficient water using equipment

At the consumer level

- o Using efficient processes in industries
- o Adapting clean technology in the manufacturing processes of industries
- o Installing low water use appliances (e.g. low flush/double flush cisterns for toilets, water efficient washing machines, low-flow shower roses/faucets, push water taps manual flushing of urinals)
- o Awareness for conservation of water
- o In-house/industrial recycling of wastewater
- o Prevention of overflowing tanks
- o Timely repair of leaks on the service line
- o Timely repair or replacement of faulty faucets and plumbing fixtures
- o Practicing water-efficient gardening
- o Use of alternative water sources (e.g. rainwater or storm water) for some household uses

Adapted from Jalil and Njiru (2006)

Application of WDM measures in several countries have yielded positive results. Many achievements in WDM by different organisations have been reported in the literature, a few examples of which are summarised in Table 2.

Table 2: Examples of benefits of WDM tools reported in the literature

Study Reference	Study setting	Action	Achievement
Martindale & Gleick, 2001	New York, USA	City Council provided rebates for installing low-volume water closets	Reduction in overall household use by 29%

Smith et al , 2001	Millennium Dome London	Use of a combination of poor ground water, grey water and rainwater for toilet flushing	Savings of about 50% of potable water consumption
Ahn & Song, 2000	Lotte World, Seoul, S.Korea	Reclamation of wastewater for toilet flushing	18% (900m3/day) of total water supply provided
Yeoh et al, 2001	Malaysia	Reusing the spent wash in molasses dilution and fermentation	40% reduction in freshwater consumption
March et al, 2004	Mallorca Island, Spain	Recycling of grey water to flush toilets at a local hotel	23% of water consumption was saved

3 Current international developments in the area of WDM

Activities under the SWITCH Project Work Package on WDM could best be classified as either managing water losses at the utility level, or managing water demand at the end-use level. These tasks can be investigated, building on the approaches developed by two task forces under International Water Association (IWA), a body that brings together leading water professionals in science, research, technology and practice. The work being carried out by these task forces is described in the following sub-sections.

3.1 IWA Task Force on water loss management

The IWA Task Force on water loss management was formed in 2002, with a mission to 'provide leadership in the development of effective and sustainable international best practice in water loss management'. Task Force members work in six focus areas comprising of (i) pressure management, (ii) benchmarking and performance indicators; (iii) leak detection methodology; (iv) real water loss; (v) apparent water loss; and (vi) district metered area practices. The most outstanding innovations of the Task Force on water loss management was the development of a model providing the definition and components of non-revenue water, and the derivation of basic elements of strategy for managing water loss, shown in Figure 1.

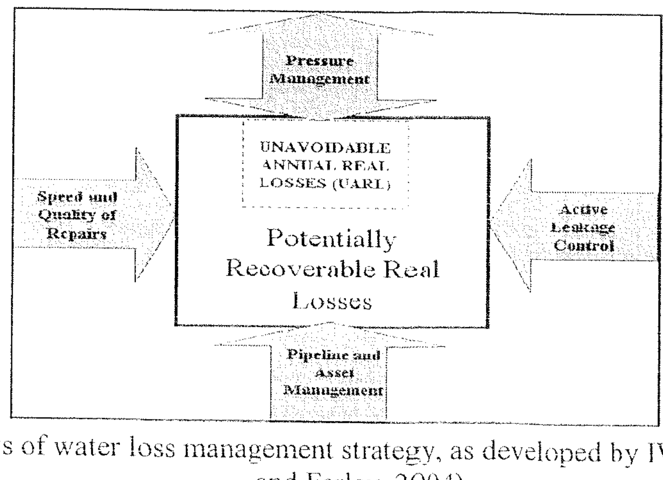

Figure1: Components of water loss management strategy, as developed by IWA (Source: Liemberger and Farley, 2004)

Building on this work, the following key tasks have been carried out by Task Force members:

- o Development of an economic level of leakage approach and calculation for best business case options,
- o Standardisation of the approach to water loss assessment and system leakage performance measures,
- o Components analysis of water uses and losses to determine water values for recovery,
- o Development of pressure management and modulation techniques for predicting bursts and water losses, in order to assess system leakage condition,
- o Development of guidance notes for setting up and managing district meter areas (DMAs),
- o Piloting and scaling up innovative techniques for leak detection programmes, and
- o Exploration of apparent water loss control strategies.

The future priority for the Task Force is to put more emphasis on encouragement and support for research activities in innovative approaches to water loss management.

3.2 IWA Task Force on international demand management framework

The need for developing an international WDM framework was identified by water professionals during an IWA specialist conference held in 2003, who noted the lack of a consistent framework for best practices in water demand management. The objective of the IWA Task Force No 7 is to develop an international water demand management framework and its associated tools that will enable water service providers to use consistent international methodology and terminology and enhance effective knowledge transfer of the latest research and skills. The Task Force is led by the Institute for Sustainable Futures, a research institute of the University of Technology Sydney, Australia.

The framework, which is currently being developed through a comprehensive assessment of best practice methodologies and experiences of implementing water demand management internationally, will highlight the importance of end-use planning alongside yield and supply-side analysis. The framework is expected to provide guidance on best practices in the following areas:

- o Water end-use data collection,
- o Water end-use analysis and modelling (i.e. demand forecasting),
- o Water demand options analysis, using least-cost analysis,
- o Sustainability assessment and evaluation of externalities, such as environmental impacts,
- o Evaluation of existing water demand management programmes, and
- o Participatory decision-making methods for values assessment, objective setting and implementation.

To develop this framework, an action research methodology has been used, in which these concepts are being tried out in Canal de Isabel II, a large water utility in Spain, one of the sponsoring organisations, and findings from one stage will influence the methodology and output of the later stages. The first draft of the framework will be applied to several case studies as a way of validating it.

4 WDM activities in the City of Zaragoza

All data used in this section was obtained from an unpublished baseline report by Victor Beuno (2006). Zaragoza City, with an estimated current population of 650,000 people, is one of the SWITCH project partner cities which is participating in Theme 3 activities. Raw water for the treatment plant is drawn from River Ebro through Aragon Imperial Canal. The conventional water treatment plant has a maximum production capacity of 510,000 m3/day, enough to serve a population of 1.7 million people, assuming a current average per capita consumption of 300 litres per day. Water is distributed to the consumers through more than 1,100 kilometres' length of a reticulation network. The network is mainly composed of pipes made of the following materials: (i) asbestos cement (34%); (ii) ductile iron (48%); (iii) reinforced concrete (6.5%) and (iv) PVCn (5.5%). The age of the asbestos cement pipes varies from 20 to 50 years, and it is suspected that leakage there from is a major contributor of non-revenue water, estimated to be 35% in 2005. Non-revenue water may be define as water produced by a utility but not billed for. Furthermore, it is also perceived by the management of the City of Zaragoza that there is a lot of water wastage at the end-use level. Therefore, to improve the efficiency of water usage and improve environmental sustainability, the management of the City of Zaragoza set targets in their 1998 corporate strategy to reduce water consumption from 79.69 million cubic meters in 2001 to 65 million cubic meters in 2010, in spite of the projected population increase.

The measures for improving the efficiency of water supply have already started paying off dividends, as by 2004, the water consumption in Zaragoza had reduced since 2001, to 70.83 million cubic meters, despite a population increase of 25,000 people. This reduction has translated into a decrease of an average per capita water consumption from 144 litres in 1991 to 125 litres in 2004. These improvements have been achieved through a combination of the following measures:

- Promotion of water saving devices, especially in public buildings
- Public education and promotion of economic use of water
- Modifying the water tariff to encourage efficient and economic use of water
- Investments in leakage control and overall asset management in the distribution network.

There is scope to work with the City of Zaragoza to enhance the water demand management strategies through application of innovative WDM tools/techniques.

5 Future activities

In the first eight months of the project, the focus of activities was on carrying out literature review to assess the current developments in the field of water demand management. This review has formed a basis for carrying activities of the work package forward. In the coming months, field work will be commissioned in City of Zaragoza and another demonstration city to be identified in due course, while at the same time keeping abreast with international developments in the field of water demand management. The work will specifically cover the following key aspects:

a. Working with the City of Zaragoza to apply IWA recommended best practices in water loss management.
b. Applying the IWA international demand management framework to Zaragoza.
c. Gaining a greater understanding of the Zaragoza economic tariff and developing it as a case study.
d. Commissioning PhD research into innovative and advanced methods of remote and non-intrusive methods of leak detection, consumption measurement, pressure zoning, and how asset management could automatically be linked with water demand management.
e. Carrying out case studies in other cities to enhance the knowledge base on water demand management.
f. Attending and presenting papers in international conferences on water demand management.
g. Carrying out training and capacity building on the topic of water demand management.

6 Conclusion

The looming water scarcity coupled with serious negative environmental impacts currently being experienced compels water sector policy makers and professionals to rethink the way they manage the water resources. Instead of focusing on supply-side options, urban water managers need to apply WDM tools in the utility distribution systems and at the end-use level. Water professionals could adapt the IRP approach, which has successfully been applied in the energy sector to manage demand. The IRP approach is based on the concept that consumers could be offered the same or even better service levels by using water more efficiently, and hence achieve the same organisational objectives with less water resources. These objectives can best be achieved by carrying out an iterative and participatory process that evaluates and assesses both the supply and demand options over a long-term horizon. These concepts, together with innovative WDM tools to be developed in the course of the project, will be applied to Zaragoza and other demonstration cities through an action research.

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