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SUSTAINABLE DEVELOPMENT OF WATER RESOURCES, WATER SUPPLY AND ENVIRONMENTAL SANITATION

Water demand management - shifting urban water management towards sustainability

Sam Kayaga and Ian Smout, UK

Whereas the world population is increasing at a high rate, especially in urban areas,, the water resources have not only remained constant, but they are being polluted at a high rate, which inevitably results in water scarcity. There is a need therefore for water sector policy makers and professionals to have a shift in the way they manage water resources in urban areas. Instead of focusing on supply-side options, we need to apply water demand management (WDM) tools both on the utility and end-user sides. This paper spells out the limitations of the conventional urban water management, provides the basic concepts of WDM and briefly introduces the five-year EU-funded SWITCH Project whose overall goal is to trigger a shift in current urban water management practices by developing, applying and demonstrating a range of tested scientific, technological and socio-economic solutions and approaches that contribute to the achievement of sustainable and effective urban water management schemes in the 'city of tomorrow'.

The looming water scarcity

The world population is increasing rapidly. The current population is estimated at 6.5 billion, having increased by a factor of four in the past century. It is projected to grow to over 8 billion by 2025 (IPCC, 2000). Water resources are essential for the existence of the human population and other members of the biodiversity. Yet the water resources have not only remained constant but have increasingly been polluted by the growing population. The rate of abstraction of freshwater has grown rapidly in tandem with human population growth. For example human water use increased by a factor of six in the past century (Andresen, Lorch & Rosegrant, 1997). It is estimated that global water withdraws will increase by 35% between 1995 and 2020 (ibid). To cope with a continuously increasing population, per capita water availability is steadily declining.

While freshwater supplies are adequate to meet demand for the foreseeable future, the world's freshwater is poorly distributed across countries, within countries and between seasons. Hence, practical distribution problems concerned with time, space and affordability lead to a widening gap between demand and supply in many parts of the world (Memon and Butler, 2006).

The water scarcity situation is compounded by the major impacts of climate change on the water resources, namely shorter duration of the precipitation seasons and increase in hydrological extremes. The shorter duration of precipitation season, probably coupled with an overall larger annual precipitation leads to larger volumes of runoffs generated over shorter time intervals, which in turn creates complications in designing for storage and routing of floods. Furthermore, the opportunity time for groundwater recharge is reduced, which undermines the efficiency of conjunctive utilization of surface water and groundwater. If these climatic changes continue at current rates, there is predicted to be a serious reduction in dry-season water availability in many regions of the world within the next few decades (Barnett, Adam & Lettenmaier, 2005). 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). Between 2000 and 2030, it is projected that there will be an increase of urban population of 2.12 billion, with over 95% of this increase expected to be in low-income countries (UN-HABITAT, 2004). Parallel with this growth in population, the demand for drinking water has been increasing rapidly in urban areas of developing countries. Yet the number of viable water resources in any country is limited and has to serve competing requirements such as domestic, industrial, irrigation, fishing, navigation, tourism, recreational, ecological and waste disposal/assimilation. Therefore, given these changes in the macro environment, water planners, policy makers and managers face tougher challenges of ensuring the available water resources are optimally used.

Limitations of the conventional urban water management concept

The current conventional urban water management concept can be traced from the 19th century, which was developed to counter epidemics caused by water-born pathogens. Hence, the design for the urban water infrastructure services was mainly driven by public health considerations, rather than environmental sustainability, and, understandably, did not take due consideration of high population growth rates, high levels of urbanisation, industrial growth and climatic change/variability we are currently experiencing. There are several major limitations that can be identified with the conventional urban water management concept:

1. The traditional 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.
2. Large quantities of water treated to high drinking standards are used for all household purposes in the urban areas. Yet, there are substantial differences in water quality and quantities demanded for different uses in the household. Only drinking and cooking, which consume a small proportion of the total household demand, require high quality treated water. The other uses can be satisfied with poorer quality water, which could permit re-use of water from one application to another.
3. The use of large quantities of water for transportation of wastes results into massive wastewater flows, which makes the wastewater management not only difficult but also costly. This situation is aggravated by use of centralised wastewater treatment plants.
4. Many managers of urban water utilities do not fully appreciate the impact their operations have on the environment, and do not recognise that every little in mitigating against environmental degradation helps. Put differently, environmental sustainability is not mainstreamed in the operational management of urban water utilities.
5. Where there are efforts to mitigate against environmental degradation, the efforts are mostly ad-hoc, and often fragmented.

Application of the conventional urban water management concept to contemporary times will not deliver the required results. Today's water sector planners, managers and policy makers are faced with enormous challenges of effectively managing the ever dwindling water resources to deliver water and sanitation services while minimising the negative impacts on the environment. 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. Water is increasingly been recognised as (Bakir, 2004):

1. A valuable resource, for health and well-being of the society and its sustainable development,
2. A finite resource, which must be used efficiently and wisely,
3. A renewable resource, which must be kept clean and its quality protected, and
4. A shared resource, which must meet the needs of competing users and future generations.

Therefore, water sector policy makers, researchers and practitioners need to adopt Integrated Resource Planning (IRP), a concept that was initially developed in the energy sector in the 1980s. The remainder of this paper describes the basic concepts of IRP and water demand management (WDM), and briefly introduces the SWITCH project, an European Union-funded five-year project involving 32 international partner institutions, which aims to create a paradigm shift in the management of urban water.

Water demand management (wdm) as part of integrated resource planning (irp)

IRP may be described as a process of planning to meet users' needs for services in a way that satisfies multiple objectives for resource use, and recognizes the fact that consumers do not demand the resource, but do generate a demand for services, i.e. end uses such as washing clothes, rather than for litres of water. These end uses can be met by increasing either the supply or the efficiency of water use (White & Fane, 2001). Increasing the efficiency of the resource use has the potential to be part of a major strategy for countering the looming water scarcity, contrasting with old "predict and provide" infrastructure models.

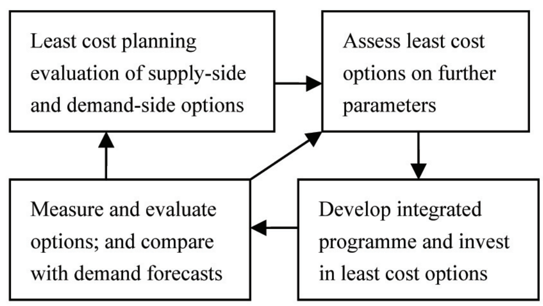

Figure 1. The iterative nature of IRP. Adapted from White & Fane (2001)

Figure 1 is a schematic diagram showing the IRP cycle. It shows that the IRP is an iterative process in which demand- and supply- side options are directly compared in order to determine the appropriate mix and achieve the least-cost outcome. The above steps should be undertaken with the full participation of the end-user stakeholders. Many factors must be considered in preparing an IRP, but the key components in a model IRP process for water supply may be listed as (Maddaus & Maddaus, 2001):

1. Preparation of a water demand forecast based on demographic trends, historical water use, economic indicators, and climate data,
2. Demand forecasts for different climatic conditions,
3. Supply side planning, by considering safe yields of existing supplies, and if inadequate for future needs, location of alternative supplies to meet all or part of future needs,
4. Demand side planning, which identifies additional water conservation measures and wastewater recycling to reduce demand, and quantifies their costs and savings,
5. Carry out a supply reliability evaluation, which examines the probability of a supply shortage in comparison with the short-term feasible demand reductions,
6. Come up with resource strategies that combine new supply development with demand reduction alternatives into a manageable number of combinations. The strategies should take account of the water quality, economic considerations, environmental impacts, and the utility policies and goals, including financial objectives, and
7. Monitoring evaluation to keep the process updated.

As can be seen from the above description, water demand management (WDM) is only a part of an integrated water resource management, which should be considered in order to redress the historical tendency of overemphasis on assessment and development of new water sources. WDM may be defined as 'those policies, measures or other initiatives which serve to control or restrict the demand of water for, use of or waste of water supplies or other water services' (Herrington, p237). WDM is a practical response to the realisation that no supply strategies can cope with the present growth and demand even in the water-rich and/or the developed countries (Bakir, 2004).

Box 1. Commonly applied WDM Measures

- Reduction in system losses, including leakage detection and repair
- Operational changes, such as pressure reduction and reduced mains flushing or reservoir cleaning
- Metering, pricing and billing reforms, such as the use of universal metering, a volume based price set at or above the marginal cost, and at least quarterly billing
- Detailed feedback systems for customers which provide information on water use.
- Comprehensive information, education, training and advisory services which assist customers who wish to take action to reduce their water use,
- Detailed water use analysis (audits) for water consumers in the various sectors
- Minimum performance standards for efficiency of equipment and appliance installed in new premises or as replacement,
- Financial incentives for purchase and installation of efficient water using equipment
- Programmes to retrofit efficient water using equipment in buildings
- Programmes designed to facilitate the reuse of wastewater or storm-water by customers

Source: White (2001)

Water demand management measures

Different categories of WDM options may be used depending on several factors, such as the stage of the water cycle, or type of consumer. Box 1 shows options commonly applied in practice. Water losses are inevitable in water distribution systems. For the service providers to successfully promote the concept of demand management on the side of the consumers, they should be able to demonstrate that they have reduced the level of losses in the water distribution network to an economic level of leakage. On the side of the service provider, water losses may be categorised as physical losses (or real losses) and commercial losses (or apparent losses). Physical losses are as a result of water leakages from pipes, joints, fittings and reservoirs. On the other hand, commercial losses consist of unauthorised water use and metering errors. A reduction in water losses on the side of the service provider requires integrated actions to address technical, operational, institutional, planning, financial and management issues (Vairavamoorthy & Mansoor, 2006).

Metering and accurate volumetric measurement of water supplies is at the centre of most demand management tools, be it for leakage control by the service provider, or on the side of the consumer. Metering and accurate volumetric measurement enables the service provider to monitor the water demand for various end-uses, and take appropriate measures for managing the demand. When used with an effective tariff structure, metering has been found to be a powerful incentive to reduce water consumption. For instance, in 2001, Canadian residential water consumers whose house connections were not metered, and who paid a fixed or flat rate used an average of 474 litres/person/day, which was 74% more water used compared to Canadians charged on volume-based water rates (Environment Canada, 2004).

The EU-funded SWITCH Project

WDM is one of the themes being explored by the SWITCH project. SWITCH is an acronym for an EU-funded five-year project that started in April this year on how 'Sustainable Water management Improves Tomorrow's Cities' Health'. SWITCH is an integrated project whose overall goal is to trigger a paradigm shift in current urban water management practices by developing, applying and demonstrating a range of tested scientific, technological and socio-economic solutions and approaches that contribute to the achievement of sustainable and effective urban water management schemes in the 'city of tomorrow (projected 30-50 years from now)'. The specific objectives of SWITCH are:

1. To develop an overall strategic approach to achieve sustainable urban water management in the city of the future,
2. To develop effective storm-water management options in the context of the hydrological cycle at urban and river basin level,
3. To explore ways of providing effective water supply

services for all at minimum impact for water resources and the environment at large,
4. To develop effective sanitation and waste management options based on the principles of 'Cleaner Production',
5. To integrate urban water services into the ecological and other productive functions of water at city and river basin level, and
6. To develop innovative, effective and interactive institutional arrangements covering the entire urban water cycle in the urban and broader river basin setting.

Water, Engineering and Development Centre (WEDC) is contributing to Objective 3 and is specifically working on water demand management issues. The objective is to develop and test holistic demand management tools, encompassing commercial and physical aspects, in order to reduce water wastage and provide educational materials on the two main components for the benefit of service providers.

Conclusion

The world population is increasing at a very high rate. Yet, the global water resources are not only finite, but they continue to be polluted by the population explosion. There is need, therefore, to change the way we manage the water resources. Water demand management is one important strategic approach to meet the challenges of increasing water scarcity. WEDC is researching these issues with a 30-50 year time horizon under the EU-funded SWITCH project, and is liaising with partners looking at other issues of sustainable water management in the cities.

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Contact addresses

Sam Kayaga
WEDC, Loughborough University
Loughborough, Leicestershire, LE11 3TU
Email s.m.kayaga@lboro.ac.uk

Ian Smout
WEDC, Loughborough University
Loughborough, Leicestershire, LE11 3TU
Email i.k.smout@lboro.ac.uk