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Water demand management: implementation principles and indicative case studies

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Abstract

Current practices for the efficient use and management of water resources are based on the conjunctive application of water supply and demand measures. Even though options for the augmentation of water supply are widely analysed and assessed, water demand management remains an open field for study, as it is highly dependent on the socio-economic features of a region and has a site-specific character. This paper summarizes the guiding principles of demand management and presents some successful application examples of demand management measures from regions that cover a wide range of socioeconomic and environmental conditions in an effort to identify the critical factors for the efficient planning and implementation of demand management plans.

Introduction

During the last decades water management has evolved through a series of paradigm shifts, as illustrated in Fig. 1. The traditional approach of water supply enhancement has been proven to be insufficient to cope with increasing water demand and meet changing standards in water utilization that emerged from the concept of sustainable water use, as introduced by the Rio Declaration (United Nations Conference on Environment and Development 1992) As a result, issues such as quality management, environmental integrity, efficient allocation of water resources and cost effectiveness were introduced in the water agenda and the efforts focused on water conservation, whereas the social aspects of water management are also being acknowledged.

Figure 1 presents five changes – shifts – in water management that are driven by increases in population and subsequently in water demand. As water availability may have remained constant or may even have been reduced, water management requires more complex and efficient tools and methods in order to supply the demand.

Furthermore, the current era in water management requires increased preparedness to cope with the uncertainty induced by global changes. The main drivers of changes in water resources planning are briefly analysed in Table 1 and refer to:

- increased water demand due to changes in life style and the concentration of population in urban centres;
- new water uses, either as new permits for water abstraction and use or as other uses (e.g. ecosystem protection, recreation);
- water scarcity problems attributed to human or physical causes;
- integration of ecosystem protection in water management; and
- climate change effects on water resources.

Adaptation to changes is thus becoming a priority in the European Union (EU) as presented both in 10EC, Green Paper (2007) and 11EC, White Paper (2009). In order to meet the changes, management practices should be flexible and able to adapt to current conditions by incorporating experience from past water projects as well as insights of the water system in planning (Pahl-Wostl 2007; Sharp 2006). Gleick (2000) stresses the importance of demand management, as a tool to support adaptive water management, because the construction of large-scale water supply projects is hindered by social, economic and environmental constraints. Therefore, emphasis must be placed on the efficient allocation and use of the existing water supplies as well as to the design the adaptation strategies

This notion is becoming even more evident in cases of extreme climate conditions, such as droughts, when water availability is limited and there is an increased risk of water system failure and environmental degradation. A series of demand management strategies (e.g. water use restrictions, water penalties and fees, information

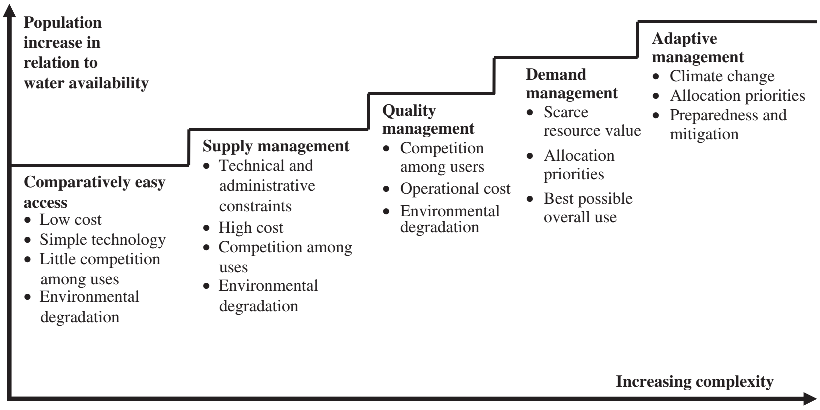

Fig. 1. Paradigm shifts in water management.

Table 1 Drivers of change in water resources planning

Increased water demand

Increased water demand is mainly attributed to population growth and economic development. Seckler *et al*. (1998) undertook an analysis of future water demand for 118 countries, accounting for the 93% of the world's population. Their analysis referred to the agricultural, industrial and domestic sector and concluded that water demand increases by 25–57% for the scenarios analysed. Any increase in water demand would result in conflict among users and neighboring countries, anticipated due to intense competition over the available water resources.

New water uses

The main dilemma in water management, could be summarized in the motto 'water for life versus for food versus for nature'. Besides the traditional water uses (i.e. agriculture, industry and domestic use) new ones are being recognized under the framework of integrated water management: ecosystem protection, pollutants dilution, recreation, fisheries, bathing, etc. The interaction among uses is complex and demands for new approaches while planning for water allocation (Rijsberman & Molden 2001).

Water scarcity

Water scarcity is defined as the imbalance between water supply and demand and could be either a supply (e.g. aridity, lack of financing for developing additional water resources) or demand (e.g. unsustainable management of the resource, lack of adaptive capacity of a society) problem. Responses to scarcity typically incorporate strategies for supply enhancement and strategies of demand management, allocative in nature (Turton & Ohlsson 1999). Even thought the traditional engineering approach has been successful in providing water to the society and the production activities, still many people do not have access to safe water resources and a shift to demand management approaches is becoming a necessity (Rijsberman 2006).

Water quality and ecosystem protection

Water and ecosystem degradation results from the uncontrolled disposal of pollutants and toxic compounds in the water bodies. Water pollution reduces the amount of available water resources and alters ecological processes that define the water and nutrient balance. The link between hydrology, water quality and ecosystem functions is the topic of research of ecohydrology that aims at enhancing the absorbing capacity of ecosystems while maintaining the ecosystem integrity and achieving the water management goals (Zalewski 2002).

Climate change

Climate change increases stress on water resources. The effects of global warming on the hydrological cycle are well known and combine long-term changes, such as the temperature increase, with a more intense occurrence of extreme events (e.g. droughts, floods), having thus significant impacts on water demand and ecosystems integrity (Iglesias *et al*. 2007). However the analysis of impacts can result to different estimates, based on the climate change scenario used in the analysis and the projection of future water use (Arnell 1999).

campaigns) are widely applied in drought situations and sometimes, have a temporary character. Typical examples are related to pricing schemes. This hinders the process of improving water users' behaviour.

Demand management, as a strategy for the efficient use of available water resources, still lacks acceptance by various stakeholders or even policy makers. On the other hand, water managers may lack the skills and knowledge to establish demand management programmes, whereas individuals prefer to 'use water as usual'. This is indicative of the fact that even though demand management is integrated in water policies, it is still considered to be a secondary management tool. The guiding water policy of the EU, the Water Framework Directive (EC 2000), defines in Article 11 that the programme of measures consists of (i) compulsory measures that include actions for meeting the requirements of relevant directives and licensing activities and (ii) optional supplementary measures that include demand management options (Fig. 2).

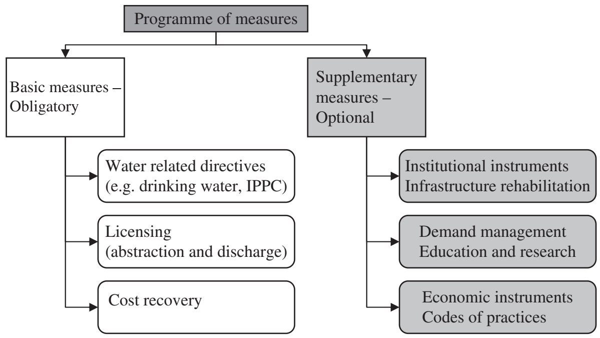

Fig. 2. Structure of WFD Programme of Measures (adapted from Griffiths 2002).

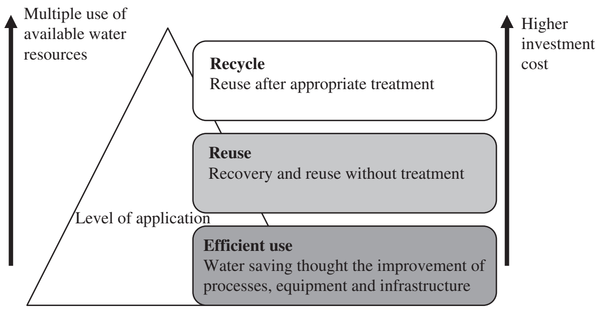

Fig. 3. Tools for the efficient exploitation of available water resources.

Demand management: instruments for the efficient use of water resources

According to Savenije & van der Zaag (2002), 'demand management aims at achieving desirable demands and desirable uses'. Under this framework, demand management is an evolving process that corresponds to the prevailing conditions at the time of application. Therefore, it can contribute to an adaptive water management strategy through the following:

- The enhancement of supply by improving the efficiency of existing water supply systems (*doing more with more raw water*).
- The increase of water productivity either by reducing the use of water or by applying reuse and recycle processes (*doing more with the same raw water*).
- Phasing out some uses while ensuring equity among users (*doing less with the same raw water*).

These goals can be achieved through the application of different types of measures (technical, institutional and economic) that may correspond to a more complex level of water exploitation or financial requirements as illustrated in Fig. 3. Mohamed & Savenije (2000) as a further step categorize demand management measures as positive or negative incentives and water-quota regulations, in an effort to assist the evaluation of the measures by water managers. In general, demand management is based on five core principles:

1. Enforce water conservation (e.g. legislation, standards).
2. Encourage water saving (e.g. positive incentives for the rational use of water such as tax refunds or voluntary agreements).
3. Invest on water saving (e.g. invest on programmes for the minimization of losses in water networks, water metering, etc.).
4. Apply economic instruments (e.g. economic incentives and disincentive, water pricing).
5. Educate water users and capacity building (e.g. setting examples, information campaigns, access to information and data).

Indicative examples, where the above principles have been applied, are provided in the following paragraphs. For each case, the selected tool is described and its results (quantitative where available) are reported. The aim is to provide illustrative examples of a variety of tools from regions that cover a wide range of socio-economic and environmental conditions.

Enforcing water conservation

The core framework for water demand management is a set of tools that define water use patterns for the different types of water users. These institutional instruments could be either institutional arrangements or command and control measures. Indicative examples are banning of sprinkler irrigation in the fields; banning of lawn irrigation during dry periods or at noon time; strict standards for indoor water appliances and plumbing; mandatory recycling or reuse in industry; and time shares in water supply. Renwick & Green (2000) performed an econometric analysis of the water use pattern in eight Californian water agencies, in an effort to examine the contribution of different demand management measures to the decrease of water use. According to their analysis, restriction (banning of uses) and rationing (fixed amount of water per household) measures accounted for 29 and 19% reduction in water use, respectively.

A prerequisite for the successful implementation of enforcement measures is the *governmental engagement* for water saving. Besides policy reform, the establishment of enforcement mechanisms is also necessary for efficient water demand management. The cases given below for British Columbia in Canada and Florida in the United States illustrate the commitment of governments to water conservation, whereas the example of drought mitigation in Athens through temporary demand management measures illustrate the effectiveness of such measures.

Water conservation in British Columbia, Canada

Water management in British Columbia is regulated by a series of action plans and legislative tools, all aiming at the sustainable use of water. Indicative examples are the Water Conservation Strategy in 1998, the Water Use Efficiency Catalogue in 1999 and the Water Sustainability Action Plan for British Columbia in 2004. Among others, the above initiatives had the following outcomes (Canadian Council of Ministers of the Environment 2005, 2006):

- In 2004, a 'Water Conservation Plumbing Regulation' was introduced that made the use of low-flow toilets in the Capital Region District mandatory. The regulation was amended in 2005, specifying that all new toilets installed must be 6 L low-consumption toilets (instead of the 14 Lflush toilets already used). As a result, the majority of population lives in cities in which low-flush toilets are mandatory.
- Water licenses are granted under the condition of reviewing water use practices.
- The Ministry of Agriculture and Food and the British Columbia Irrigation Association compiled guidelines on best irrigation practices to be applied by farmers.
- Infrastructure grants are approved on the basis of proving the existence of water audit and leak detection projects.
- A 'Water Save Tool Kit' was developed as a knowledge base on water conservation practices for individuals and communities.

Water reuse programme in Florida, United States

Under the framework of the Water Conservation Initiative, the Department of Environmental Protection of the State of Florida runs a water reuse programme that involves the definition of rules for water reuse, permitting activities, the funding of reuse projects, etc. (WRWG 2003). Among others, the Florida Administrative Code defines that:

- Reuse of reclaimed water is mandatory and should be integrated in water and wastewater management programmes.
- A feasibility study of treated wastewater reuse is required in order for a domestic wastewater facility to receive a permit in 'Water resource caution areas'.

This is indicative of the fact that the South Florida Water Management District has spent over US$26 million since 1995 in alternative water supply (water reuse, use of brackish water, storage in aquifers) grants that resulted in over 250 million gallons per day of water being made available.

Water conservation in Athens, Greece

The city of Athens in Greece suffered from an intense drought in the beginning of the 1990s. Drought management measures fell into the two broad categories of supply augmentation and demand decrease. Demand management measures included information campaigns, the increase of water price and the introduction of strict regulations. The latter involved (Christoulas 1994; Xenos *et al.* 2002):

- Banning and fining the use of drinking water for irrigation, car washing and filling swimming pools.
- Definition of upper water use level per person using literature data. In case of exceedance of this limit, the consumers had to pay a fine.

Even though pitfalls were reported with regard to the implementation of the measures, the overall campaign resulted in a decrease of water consumption by 35% in 1993 and by 25% in 1995 of that in 1989 (Karavitis 1998), which was the highest recorded consumption (Kaika 2003). However, when the drought phased out, the water consumption levels reverted to the original values, as the restrictive regulations had been abandoned (Xenos *et al.* 2002), indicating the strength of the measure.

Encouraging water saving

One of the most efficient tools for water saving is public engagement for the implementation of policies and consequently for wise water use. This can be achieved by providing incentives for water-saving practices (e.g. tax refunds for installing water saving or reuse appliances, motives for process change in the industry) or for mapping water use (i.e. water audits in public buildings or industries). Programmes of incentives can be designed and implemented either by water utilities (see the examples below for Singapore and Sydney) or water management institutions (see the examples below for the United Kingdom and Cyprus). Their successful implementation depends on the *efficient interaction* between the water user and the management authority. In the case studies given below, the agencies appointed staff for assisting water users on designing and implementing their conservation plan and provided a list of products or water-saving appliances so as to ensure that the equipment installed will meet the standards.

Water saving, Singapore

The National Water Agency of Singapore is being recognized as one of the most efficient water management agencies; it is indicative of the fact that the company has won a lot of international awards for excellence in water management (e.g. the Stockholm Industry Water Award at the World Water Week in Stockholm in 2007, the 'Environmental Contribution of the Year' Global Water Awards 2008 for its project on reclaimed water). One of the main components of its strategy is to conserve water for ensuring the sustainability of the water system. Through a series of conservation programmes, the domestic water consumption was reduced from 165 L/cap/day in 2003 to 158 L/cap/day in 2008, with a targeted value of 155 L/cap/day for 2012. The water company runs two types of programmes:

- The Water Efficiency Fund that deals with co-funding of water conservation activities for domestic and industrial water users.
- The Water Efficiency Labelling Scheme of products, according to the water use level.

Water saving in Sydney, Australia

Water conservation is the main goal of Sydney Water, a company that provides water and wastewater services to cities of Sydney, Illawarra and the Blue Mountains in Australia. In order to ensure water supply for the future, the utility developed a water-saving plan that is based on three axes: the construction of a desalination plant, the promotion of recycling and water saving. The measures for water saving are presented in Table 2, whereas some key achievements for the period 2006–2007 were as follows (Sydney Water 2007):

- One out of four homes have benefited from the water-saving measures, resulting in a saving of around 10 000 million litres of water a year.
- Around 54 000 washing machine rebates and 36 500 rainwater tank rebates have been paid, resulting in a saving of 2700 million litres a year.
- Three hundred and sixty-nine businesses were introduced to the 'Every Drop Counts' programme, resulting in a saving of 11 000 million litres a year.

Enhanced capital allowances for businesses to invest on water-saving technology, United Kingdom

The UK government introduced the Enhanced Capital Allowance (ECA) scheme for water technologies under the framework of the so-called Green Technology Challenge. According to the provisions of the scheme, businesses can claim up to 100% of the first year capital allowances for investments on sustainable water use. A first list of eligible products and technologies was developed in 2003, with this being revised annually to account for advances in water technology.

Information on the scheme, as well as indicative case studies, is provided in the relevant website. For example, Unilever is one the companies that used the ECA scheme for investing in water-saving appliances. As a result, the water use levels in the company have decreased by 40% since 2005.

Subsidies for water-saving actions, Cyprus

Cyprus suffers from water scarcity attributed to the semi-arid conditions and the high water demand, especially during the summer period. Efforts to cope with water deficiency include the operation of desalination units, wastewater reuse, water restrictions in periods of water crisis (i.e. drought events) and water-saving programmes (Charalambous 2001). The Water Development Department, responsible for the management of water resources, bases its water conservation strategy on programmes of subsidies for encouraging saving of potable water. For example, 6.5 million cubic metres of recycled water were used for irrigation purposes for 2006 (Cyprus Water Development Department website, Annual Report for 2006).

The programme for the year 2008 (valid until 1 December 2008) also promoted grey water recycling and the installation of hot water circulators.

Investing on water-saving technology and programmes

Water-saving technology aims either to a more effective use of water or to multiple uses of available resources (reuse and recycling). The most widely known water-saving technology is drip irrigation and low-flow (or variable flow) flushing systems, whereas grey water reuse is gradually becoming popular. In Cyprus, for example,

Table 2 Measures for encouraging water saving in Sydney water (Sydney Water website as in 17 September 2008)

Water saving in home	Water saving in the garden	Water restrictions	Water saving in business
Provision of a free saving kit Low cost installation of water saving devices (payment of US$22 instead of US$180 to a qualified plumber) Rebate of US$150 for buying water efficient washing machines Rebates for installing rainwater tanks (up to US$1500 for houses and US$2500 for schools)	Provision of low cost horticulturist services (payment of US$33–55 instead of US$150) Rebates for installing rainwater tanks (up to US$1500 for houses)	US$220 fine for individuals and US$550 for corporations in case of not compliance with the restrictions (e.g. irrigation schedule, pool permits, use of trigger nozzle etc)	Every Drop Counts Business Programme: Free of charge assistance for performing a water audit and developing a water management plan for large-scale water consumers Water Saver Grant: Funding half cost of water saving projects for small & medium scale businesses Smart Rinse Programme: Free replacement of rinse spray valves for small & medium scale businesses

1.5 million cubic metres of potable water were saved in the period 1999–2006 by investing by means of subsidies in indoor wastewater recycling (Cyprus Water Development Department, Annual Report for 2006). Investments in water saving technology should be included in the *yearly budget* jointly with other conservation activities (e.g. infrastructure repair), thus making water conservation plans an important activity of the water agency.

Free provision of water conservation devises by the Portland Water Bureau, United States

The Water Bureau of the city of Portland in Oregon is responsible for the supply of drinking water to the citizens as well as to 19 neighbouring cities and water districts. In order to balance water demand and supply during the dry summer months, the Water Bureau develops water conservation programmes and furthermore encourages the installation of free water-saving devices (e.g. kitchen faucet aerator, 5-min shower timer, watering gauge) and free audit kits (flow meter bag, drip gauge, toilet tape measure, leak detection tablets). All information is available on-line (http://www.portlandonline.com/water/) and customers can order the devices either on-line or by contacting the Water Bureau. For example, 13 624 devices were distributed in the 2008–2009 fiscal year, whereas the Water Bureau costumers highly appreciate the decrease in their water bills.

Rebates for the installation of water conservation devices by the Contra Costa water district, United States

The water district of Contra Costa serves the central and eastern Contra Costa County in Northern California. It runs a water conservation programme in order for the district to be prepared for droughts and to ensure future water supply. The conservation programme, besides other benefits, includes incentives for installing water-saving devices:

- Provision free of charge of water conservation kits (e.g. two flow kitchen aerator with swivel, low flow bathroom faucet aerator, six spray pattern hose nozzle).
- Rebates for installing water efficiency appliances (clothes washers, toilets, sprinkler timers, irrigation equipment and other commercial rebates.

According to the annual report for the year 2007, the water savings account for 4.07 million cubic metres (CCWD 2007).

Water saving in a cold storage company, Australia

The Environment Protection Authority Victoria (EPA Victoria), in cooperation with the Victorian Employers' Chamber of Commerce and Industry, has developed the programme 'Grow Me The Money', in an effort to guide small- to medium-sized businesses towards more sustainable practices in the fields of water, waste or energy.

The businesses that join the programme and achieve measurable reductions in at least one resource are assigned 'Gold club members'. One of them is the Oxford Cold Storage company, which provides cold storage for Australian manufacturers. The company invested in a rainwater-harvesting system from the roof, which resulted in savings of up to 100 000 L/day, whereas the estimated amortization period is 7–8 years.

Applying economic instruments

Economic instruments are becoming an important tool for providing incentives towards 'more environmental friendly' behaviour of water users. Economic instruments may be classified into four broad categories (Policy Research Initiative 2005a): (i) property rights, (ii) fee-based measures, (iii) liability and assurance regimes and (iv)-tradable permits. The most popular tool is water pricing because water users are directly affected and water demand decreases significantly.

Current practices differentiate water price according to the user type (domestic, industrial or agricultural) and the period of water supply (season or time-peak hours) and should account for the full cost of water as proposed in the WFD (EC 2000). Cost recovery is the main goal of water pricing in order to ensure the sustainability and the quality of water services. A prerequisite is the link between consumption and cost; therefore, volumetric pricing schemes have been proven to be the most effective for water demand management. The *effectiveness of pricing* depends on:

- Proper water metering and distribution of cost (e.g. water rates in the Irvine Ranch Water District in California and abstraction rates in the Netherlands – both cases are presented below).
- The existence of a transparent procedure for the estimation of costs and financial planning (e.g. the irrigation pricing scheme in France, which is presented analytically in the following section).
- Independent regulators.

However, equity in access to water is a no-negotiable right and water pricing should not exclude people from being supplied with water for their basic needs. Therefore, pricing schemes should correspond to a number of features of water users and be adapted to meet their needs either by applying increasing block (volumetric) water rates or by using governmental subsidies for specific user groups.

Water pricing of irrigation water, France

The basis for water resources management in France is the Water Law of 1992. In relation to the agricultural water use, the Law specifies that the farmers should install water meters in order to measure the real water use and the water price is defined by the irrigation companies, who usually specify prices in order to recover the long-term incremental costs (Nagaraj 1999). Typically, the pricing scheme comprises two parts (Rieu 2005):

- Abstraction charges at the basin level: Rates are calculated on the basis of the principle 'the polluter pays', taking into account either the volumetric water use or the area of irrigated land. The charges partly integrate the environmental cost of water withdrawals.
- Water supply rates in collective systems: Water prices are formulated on the basis of negotiations among the Basin Agency, the Irrigation Project Manager and the farmers' associations. The starting point of negotiations is the average cost per hectare for the depreciation of the water infrastructure.

Rieu (2005) states that 15–60% of the capital cost is charged to farmers, whereas the public financing of operation and maintenance costs is minimized. Massarutto (2002) in his analysis reports 100% coverage of the operational cost and a range of 35–100% of full cost recovery.

Water rates in Irvine Ranch Water District in California, United States

The Irvine Ranch Water District serves the city of Irvine and some suburban areas. The district bases its conservation strategy on water pricing, introducing a five-tiered rate structure since 1991 (EPA 2002). The structure characterizes users from low-volume users to wasteful and besides the consumption charges, the users pay a fixed water fee based on meter size. The money raised from penalties for excess water use is used for financing water conservation programmes (e.g. rebates for water-efficient appliances). The conservation programme led to a decrease in water consumption by 19% during the first year of application, whereas the customers' approval on the tariff structure was about 90% (EPA 2002).

Abstraction charges, the Netherlands

Abstraction charges are used for discouraging water use (i.e. minimizing abstraction quantities) and are usually applied complementary to the abstraction licensing process. In the Netherlands, abstraction charges apply only to groundwater resources, which are the main water resources of the country. There exist two abstraction charges: one imposed by the provinces for groundwater protection and water planning and the other is part of an ecological tax reform that focuses on the consumption of natural resources (Zabel *et al.* 1998). The tax is active since 1995 and has two tariffs: one standard rate for the water works and a lower rate for other extractors (e.g. agriculture) (Hellegers & van Ierland 2003). In the case of industrial water use, the introduction of the charges led to a decline in water use between 2 and 12% (Policy Research Initiative 2005b); however, this was not achieved for small-scale extractors, such as households, and therefore, the government introduced a new tax in 2001 for water supply up to 300 m^3/connection/year (Laskowska & Scrimgeour 2002).

Education and capacity building

A common motto in water management is that 'an informed user is a better user'. Water users are stakeholders who usually are not aware of their rights and obligations. Information campaigns on water-saving options at home, education programmes in schools, information offices, financing of educational programmes for the more efficient use of water in industry and for irrigation can contribute to a more active involvement of the public in water-saving efforts. Besides, access to information, inclusion and participation are two main elements for successful community empowerment (World Bank 2002). Gumbo *et al.* (2004) also recognize that an important element in water demand management is to audit skills and the training needs of the people that compose and carry out water management programmes. Therefore, the key factor of any conservation plan is to have *informed users and managers*.

Raising awareness on improved irrigation practices, India

Irrigated agriculture is an important economic activity in India. According to the World Bank (1998), irrigated fields account for about 67% of agricultural output and in order for the agricultural sector to continue to grow, a shift towards enhancing productivity and improving the performance of existing irrigated infrastructures is required. In this context, a reform in the irrigation sector was promoted in the state of Maharashtra, which is considered to be one of the most successful in India. The reform is briefly described by Sodal (2004) and includes policy, technological and management instruments, with emphasis also placed on increasing farmer's awareness as well as training the personnel on improved irrigation practices. The programme resulted in a 21% reduction in water use in 2000–2001 compared with the value for the year 1999–2000. The main features of the awareness and information campaign are given below:

- Establishment of study groups (consisting of head managers, field officers, agriculture and socio-economic experts) in public authorities to study and provide in-depth reports on crucial topics for irrigation water management.

- Organization of workshops and conferences in order to share the experience and knowledge from various parts of the country.
- Farmers' training through on-farm training, farmer camps, exhibitions, study tours, organization of Water Users Associations Awareness Weeks.
- Educational empowerment by distribution material on water use in primary and higher schools.
- Involvement of NGOs to facilitate the participation of farmers in irrigation water management.
- Strengthening of the cooperation between academic institutions and field practitioners.

Improving water use in schools, Cape Town city, South Africa

The city of Cape Town runs a successful water demand management programme that was awarded in 2008 by the Department of Water Affairs and Forestry at the 'Water Conservation and Water Demand Sector Awards'. The overall strategy consists of (i) water leaking control programme, (ii) pressure management, (iii) re-use of treated wastewater, (iv) education programmes in schools and (v) awareness campaigns.

The preliminary results of the education programmes that run in schools are reported by Wilson (2004). The objectives of the programmes were dual: to promote a water-saving culture within schools and to minimize water consumption by installing special kits in toilets. Two hundred and six schools were visited during February to June 2003, where a low-flush device (plastic bag) was added in the toilet cisterns. The estimated yearly water savings are 160.293 kL, whereas the city of Cape Town estimates that the money saved by schools, due to the reduction of water use, are almost 400% more than the cost of the project.

Capacity building on improved water management, Mexico

Even though integrated water resources management is a primary goal for the country of Mexico and numerous efforts have been made to this direction, a main challenge for water managers involves the improvement of water services in terms of sustainability, economic efficiency and equity (Asad & Dinar 2006). A main constraint to this process is the lack of well-trained managers and, as proposed by the World Bank (1996), numerous efforts have been made to improve capacity building and restructure water offices, at the different administrative levels. Tortajada (2001) summarizes the activities undertaken by several institutions on capacity building during the 1990s:

- 1990: Initiation of a post graduate training course, with the support of the Mexican Institute of Water Technology, to improve the knowledge of existing staff on water management.
- 1992: Identification of training needs through staff interviews that focused on management and technical development.
- 1995: Development of the national programme on capacity building under the supervision of a UNDP expert.
- 1995: Assessment of capacity building requirements, carried out jointly by the National Water Commission of Mexico and the World Bank.
- 1996: As part of the of the Water Resources Management Project, funds were allocated to training of the professional staff.
- 1998: Establishment of the National Centre for Transfer of Technology on Irrigation and Drainage that aimed at training technicians and users.
- 2000: Establishment of the Mexican Centre for Training in Water Supply and Sanitation, which provides training to water utilities staff.

Criteria for selecting demand management tools

As also presented by the selected cases studies, demand management refers to the implementation of a strategy that combines institutional, technological and economic instruments, all contributing to more efficient water use. Water managers should analyse and evaluate all available tools and select those that best fit the water use profile and socio-economic characteristics of the region, using the following criteria:

- Financial feasibility to cover the cost of demand management projects.
- Economic efficiency; Griffin (2006) proposes the term of social economic efficiency as the goal to 'maximize the total value of water (before processing) across all users, or equivalently, maximize the total net benefits (after processing) across all users'.
- Cost recovery and reflectivity, accounting for the environmental, financial and resource cost of water service provision and indicating the scarcity value of water (Assimacopoulos 2006).
- The timescale of application, as the necessary time for the users to adjust to measures varies and not all tools can exert immediate effects on water use patterns. Table 3 indicates measures that can be included in short-term or long-term water planning as well as in the case of water crisis (e.g. a drought event).
- Monitorability, in order to measure the actual change in the water use pattern.
- Equity in water access.

Table 3 Water saving planning and application of tools

	Short-term planning	Long-term planning	Crisis management
Investment on technology	Repairing of equipment Decrease of pressure in water networks Leak detection programmes Rain tanks on roofs	Recycling Improvement of equipment	Reduction of water supply Intermittent water supply No water supply
		Enforcement–encouragement–education	Legislation
Water consumption metering programmes Education of water users	Information and mobilization campaigns Advertisements Community engagement		
Economic instruments	Water pricing reform Tradable water rights	Marginal cost of water Integrated water demand and supply management	Fees/penalties Noncompliance measures

Table 3 presents a number of tools and actions that are related to different planning schemes: short term, long term and crises. Measures applied in crises situations are typically temporary in nature and aim at meeting water demand under the prevailing water availability conditions. However, water managers should go beyond temporary measures and promote a water conservation culture among water users and planners. This stresses the need for an integrated demand management programme that emphasizes on proactive planning rather than crisis management.

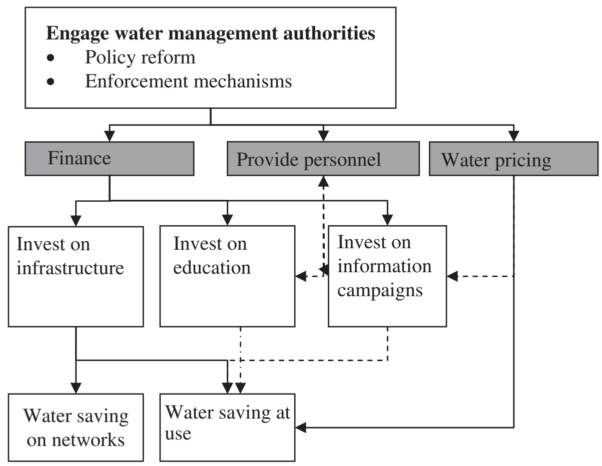

Fig. 4. The demand management path towards water saving.

Conclusions

The decision regarding whether to follow demand or supply management measures is not always straightforward in water planning. Supply augmentation typically gained support; however, under the framework of sustainability and adaptation to change, a feasibility study and a cost analysis may be important, with water resources conservation playing a central role in the sustainable use and management of water, as also suggested by the WFD.

This paper summarizes the guiding principles for developing demand management strategies and presents a number of actions and instruments that can be applied in order to manage and conserve water resources. The results indicate that water saving is possible as long as there is direct governmental engagement with a robust enforcement mechanism. The results can be even more efficient when a clear implementation framework has been organized. Therefore, the critical factors in the implementation of a water conservation plan interrelate, as shown in Fig. 4 and are briefly given below:

(1) Engagement of water authorities for performing water conservation plans
(2) Establishment of a link between water users and water managers
(3) Financing of water conservation plans
(4) Development of an adaptive water pricing scheme, ensuring the approval of water users
(5) Investment on human resources by informing water users and educating water managers
(6) Investment on infrastructure

The case studies presented in this paper focus on a particular type of demand management action that is part of a wider water demand management strategy. An efficient water conservation action plan consists of all types of measures, aiming at reducing water demand in the future. Furthermore, options like water pricing, public participation and engagement in water management, fostering water-efficient technologies and practices are promoted as important elements for developing drought-resilient societies and water systems.

The review of the case studies could lead to the following conclusions:

• It appears that measures that are related to economic instruments exert more direct effects on the control or reduction of the consumption.

• Supply enhancement is usually related to allocation of alternative sources, and usually, this is done either by recycling or by reusing waste or grey water. The option of rainfall harvesting is also an approach that can provide substantial amounts of water; however, it has a more ephemeral nature and can supplement the main sources.
• Demand management options are more diverse and have been driven by long-term strategy planning or crisis management.
• An interesting attribute between the different cases studies is related to the socio-economic drivers that, to some extent, limit the selection of available options. It can be seen that in developing countries, focus is placed more on raising awareness to both managers and consumers than on fines or water pricing policies.

The development of databases, where the description and results of demand management options could be reported, could be of value for water mangers. Particularly, the dissemination of knowledge gained from the implementation of a variety of tools could enhance national and regional efforts for ensuring water supply. Past failures and successes could guide future actions towards water security.

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