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Demand Management in Zaragoza: Past Achievements & Way Forward

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Abstract
Demand Management (DM) is one of the key components of Integrated Urban Water Resources Management (IUWRM), an approach that is the foundation for the SWITCH project. DM 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 a resource. Under the SWITCH project, the demonstration city for DM research activities is Zaragoza, Spain, which experienced a serious drought in the period 1991 to 1995. As a result, the Fundación Ecología y Desarrollo, a Spanish environmental Non-Governmental Organisation championed the multi-phased 'Zaragoza: Water Saving City' project starting in 1996, in which key stakeholders have actively been participating in water conservation measures. The project is currently in the fourth phase.
An evaluation survey curried out at the end of the first phase in 1999 showed that awareness of water-saving measures improved from 40% to 72%, and the campaign resulted into an overall annual saving of 1.176 billion litres of water, equivalent to 5.6% of annual domestic consumption. However, the same survey also found out that most of water savings were a result of behavioural change and cost-reflective pricing. For DM to be sustainable, there is need to use a much wider range of DM measures. Hence SWITCH research activities will build on existing work to widen the scope of DM activities, by adopting an Integrated Resource Planning (IRP) approach.
This paper highlights the results so far achieved from the NGO-spearheaded water conservation programme and cost-reflective pricing. It also describes preparatory stages of SWITCH project activities in two areas: application of advanced water loss management in one of the water supply zones in Zaragoza, based on the IWA recommended strategy; and adoption of IRP approach for overall sustainable water supply planning in Zaragoza.

Keywords: demand management, communicative tools, economic tools, water loss management, integrated resource planning

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1 Introduction

While the population in many industrialised countries is either decreasing or constant, the population in most developing countries is increasing rapidly, resulting in an overall global population increase. The most recent UN world population prospects report estimated that the global population reached a mark of 6.7 billion in July 2007, 5.4 billion of which live in developing countries (United Nations, 2007). But 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. Consequently, per capita water availability is steadily declining. The water scarcity situation is compounded by the major impacts of climate change on the water resources, and the practical distribution problems concerned with time, space and affordability, leading to a widening gap between demand and supply in many parts of the world.

According to UN-HABITAT, 2007 is a historical year in which the number of people living in the worlds' urban population hit a 50% mark (UN-HABITAT, 2006). The water scarcity situation will escalate in the urban areas where it is projected there will be a population increase of 2.12 billion people between 2000 and 2030, 95% of which will occur in developing countries (UN-HABITAT, 2004). The current conventional urban water management concept, which was developed in the 19th century mainly to counter epidemics caused by water-born pathogens, cannot adequately respond to the changes enumerated above. The situation calls for the adoption of integrated urban water resources management (IUWRM), which forms the bedrock of the SWITCH (Sustainable Water management Improves Tomorrow's City Health) project.

The principal components of IUWRM are supply optimisation; demand management; participatory approaches to ensure equitable distribution; improved policy, regulatory and institutional framework; and intersectoral approach to decision-making (UNEP-International Environmental Technology Centre, 2003). Working through a variety of work packages, the five-year SWITCH project is applying the IUWRM concepts to develop efficient and interactive urban water systems and services in the city's geographical and ecological setting, which are robust, flexible and responsive to a range of global change pressures.

Demand management (DM), one of the IUWRM components 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). DM 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. There are five major categories of DM measures (White and Fane, 2001): those measures that (i) increase system efficiency at the utility level; (ii) 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.

Under the SWITCH project, the demonstration city for DM research activities is Zaragoza, Spain, which experienced a serious drought in the period 1991 to 1995. As a result, the Fundación Ecología y Desarrollo, a Spanish environmental Non-Governmental Organisation championed the multi-phased 'Zaragoza: Water Saving City' project starting in 1996, in which key stakeholders have actively been participating in water conservation measures. The project is currently in the fourth phase. Furthermore, the City of Zaragoza has been working with the University of Zaragoza to carry out research on how pricing policies could influence residential water demand. This paper highlights the results so far achieved from the NGO-spearheaded water conservation programme and cost-reflective pricing. It

also describes preparatory stages of SWITCH project activities in two areas: application of advanced water loss management in one of the water supply areas in Zaragoza, based on the IWA recommended strategy; and adoption of IRP approach for overall sustainable water supply planning in Zaragoza.

2 'Zaragoza, the water-saving city' Project

Following a serious drought in Spain during the period 1991 to 1995, Zaragoza City Council imposed a variety of water restrictions, which prompted displeasure from the customers. The droughts also sparked off disagreements and confrontations between various regions of Spain about mass transfer of water through building dams, tunnels and channels. These incidences motivated Fundación Ecología y Desarrollo (FED), a Spanish environmental Non-Governmental Organisation (NGO) to develop a pilot project that aimed at demonstrating that the water shortage problem could be solved using a cheaper, more environmentally friendly, and socially acceptable approach (Fundación Ecología y Desarrollo, 1998).

Working with various partners, FED initiated the 'Zaragoza: Water Saving City' project in 1996, whose objectives were to (i) create awareness of the need for water-saving; (ii) promote information about simple water-saving technologies; (iii) work towards creating a water-saving city, which would be set an example for the outside world; and (iv) save water without sacrificing comfort. With a budget of 0.87 million euros variously contributed by the founding partners, the first phase of the project kicked off in February 1997, for two years, while the second phase run from 2000 to 2002. The first phase, focusing on 'small steps, great solutions', sought to have a systematic focus on all that individually and institutionally determine a water culture such as institutional policy framework, technology, knowledge/information, regulations and consumer habits.

It was recognised right from the project inception that improving a water-saving culture was a collective challenge, and required the full participation of all stakeholders that contribute to the water culture. Based on the principle of shared responsibility, the intervention was therefore designed to create a collective challenge which would bring about participation of all stakeholders in the city, and build on the synergy of these partnerships. Participation in the project was deliberately sought from all key stakeholders such as consumers, plumbers, policy makers, manufacturers, retail outlets, businessmen, building companies, financial institutions and architects. The following actions were promoted among the various partners: (i) change of attitude towards water use and consumption, leading to behavioural change; (ii) provision of information, education, training and advisory services which assist consumers who wish to take action to reduce their water use; (iii) replacement of old equipment with new water-saving devices; (iv) acquisition of new water-saving sanitary fittings (e.g. flushing toilets, taps, showers) and household appliances (e.g. washing machines and dish washers); (v) the introduction of individual household hot water meters; and (vi) other actions that would save water, such as timely repair of leaks in the premises, and recycling of domestic water.

By the end of the first phase of the project, over 150 organizations were actively involved in project activities, such as distribution of information. The active partners included public institutions, NGOs, private companies, trade unions, professional bodies, community-based organisations and business associations. About 90% of the media houses in Zaragoza fully participated in the project. Furthermore, over 140 wholesale and retail establishments selling products related to water consumption, accounting for about 65% of all the traders, collaborated in the campaign. From the educational sector, 474 teachers and about 70,000 pupils from 183 schools collaborated in the

educational programme on water-saving culture (Fundación Ecología y Desarrollo, 1998). Clearly, in the two years of the first phase of the project, FED, the leading project partner successfully mobilised partnerships for enhancing water-saving culture in Zaragoza.

Although the first phase of the project aimed at saving at least 1,000 million litres of water in the homes of the city of Zaragoza per year, the project achieved an overall saving of 1.176 billion litres of water, equivalent to 5.6% of annual domestic consumption. (Fundación Ecología y Desarrollo, 2001). An evaluation survey carried out at the end of the first phase in 1999 showed that the number of people aware of the importance of water-saving measures improved from 40% to 72% of the respondents. However, the same survey showed the water saved was more as a result of behavioural change than adoption of water saving technology (Edo & Soler, 2004, Fundación Ecología y Desarrollo, 2001). Hence, a second phase of the project was initiated in the recognition that there was need to have an integrated strategy encompassing, among other methods, campaigns for behavioural change and adoption of water-saving technology, if the water conservation measures were to be sustainable.

The second phase of the project, entitled 'Zaragoza, water saving city – 50 good practices' was initiated to widen and extend the intervention to non-domestic sectors, and consolidate the achievements realised by emphasising the use of water-saving technology in the households. This phase was implemented from June 1999 to March 2003, and aimed at developing 50 best practices for efficient water use in selected public buildings, industries, and parks/gardens, such that these demonstration centres become a reference and model for others in the respective sub-sectors (Edo & Soler, 2004, Fundación Ecología y Desarrollo, 2001).

By the end of the second phase, 30 good practices were achieved in efficient water use in buildings for public use. Typical examples are a shopping mall that achieved 92% water savings through a change in floor cleaning methods and an educational centre that saved 70% through environmental education. Similarly, 13 good examples were established in the parks/gardens sub-sector, mainly through careful consideration of the design of the lawns, selection of the plant species, and watering methods. In industries, huge savings were made in at least 9 enterprises through modification of the production and cooling processes, ranging from water recycling, water recirculation and reverse osmosis (Edo & Soler, 2004). Furthermore, practical guidelines for efficient water use in the non-domestic sector were published and widely circulated. These publications include practical eco-audit guidelines for hotels, offices, industries, hospitals and educational institutions; and dry-land gardening (Garrido et al, 2005).

Similarly, audits were also carried out in selected households, with the aim of promoting water-saving technology. As a result, a practical handbook on efficient water use in the homes was produced, which provided guidelines for householders to evaluate their water consumption rates, and adopt good practices for water use efficiency by installing technological devices and changing their habits. Households were offered subsidised kits of household water-saving devices, such as shower heads, tap devices and double-flush cisterns. These devices were installed in the households at a subsided cost. Activities involving use of water-saving technology were carried out in full collaboration with the enterprises concerned with manufacturing, distribution and/or installation of the water-saving devices. Technical staff from firms were continuously sensitised, were kept informed of the project activities, and their profiles were widely promoted to the consumers.

The overall outcome of both phases of the project 'Zaragoza: the water-saving city' have been quite significant. Average water consumption in the households of Zaragoza reduced from 107 litres per capita per day in 1996 to 99 litres per capita per day in 1999 (Garrido et al, 2005). These figures are well collaborated with operational data for Zaragoza City Council, which show that, with an increase

in population of 6.3% between 1996 and 2004, water supplied to the city reduced by 14% during the same period (Zaragoza City Council, 2006). To consolidate these achievements, another phase was launched in November 2006. 'Zaragaza, a water saving city: 100,000 commitments' aims to solicit for commitments for achieving efficient use of water by individual consumers.

3 Towards Economic Pricing for Water Services in Zaragoza

By the time of the extended drought that ended in 1995, the water tariffs set by Zaragoza City Council, the service provider, were mainly driven by financial and political considerations, rather than economic considerations. The tariff, which was comprised of a fixed fee and a volumetric-based rate, ensured that revenues cater for a politically acceptable part of the costs of providing water services (Arbués and Villanúa, 2006). The monthly fixed fee was based on the street category where the building was located, and mainly depended on the length/width of the street, and whether there were any commercial enterprises. Not enough quantitative data were collected to determine these rates, and therefore, there were cases where the rates were allocated based on political criteria (Arbués and Villanúa, 2006). On the other hand, the volume-based rates were categorised into four blocks, as shown in Table 1. However, there were quite a few properties that did not have consumption meters. Furthermore, as can be seen in Table 1, there was no differentiation between domestic and non-domestic tariffs. Therefore, the tariff structure did not necessarily take into consideration the economic value of water, nor did it fulfil social equity obligations.

Table 1: Zaragoza variable tariff in 1993
(Source: Key informant, Zaragoza Finance Department, 2007).

Consumption Range	Price (Pesetas* per m3)
0 - 6 m3 per property per month	12
6.1 – 13 m3 per property per month	25
13.1 -35 m3 per property per month	40
Over 35 m3 per property per month	56

*The Spanish Pesetas was replaced by the Euro in 2002 at an exchange rate of 166.4 pesetas to 1 Euro.

Zaragoza City Council initiated a long-term programme to reform the tariff in 1995, in which changes were implemented in a step-wise fashion. As part of the programme, an empirical study was carried out by the University of Zaragoza from 1996 to 1998, to test short-term sensitivity of water demand to changes in price and key socioeconomic variables. This study used a longitudinal survey of a sample of 1596 households, and obtained data on a set of 10 water consumption meter readings, the price paid, daily maximum temperature, educational level and age of head of household, household size and availability of a common hot water facility in each household (Arbués and Villanúa, 2006). The key findings of study were as follows: (i) the average price elasticity of demand was –0.0811; (ii) the average income elasticity of demand was 0.7919; (iii) the average elasticity of water consumption with respect to family size was 0.4794; and an installed collective hot water storage system leads to an average fall of 15.42% in the consumption registered on the individual household meter (Arbués and Villanúa, 2006). Other key findings were that every household required an average basic minimum amount of 3.5 m^3 per month to maintain the common good in the home, while each resident required additional 2.5 m^3 of water per month, which decreased with household size, along economies of scale.

The results highlighted above were used to inform the design a tariff that aimed at engendering optimization of economic efficiency; horizontal and vertical equity (i.e. same benefit, same cost, and different benefits, different costs); universal access and transparency. Tariff structures that have

operated since 2005 have been designed to match the socioeconomic attributes and consumption habits of the population. The tariff is composed of fixed and variable parts as shown in Table 2. Whereas consumption falling in block 1 and 2 attract some subsidies, the price levels in block 3 cover full supply costs. In order for households with more than six people to benefit from these subsidies as well, there is a provision for them to be charged on a special tariff rate, after their claims have been verified by the responsible utility staff. Other categories of people that benefit from special tariffs are the unemployed, the sick and the poorest of the poor.

Table 2: Zaragoza domestic variable tariff by end of 2005
(Source: Key informant, Zaragoza Finance Department, 2007).

Breakdown	Consumption Range (per property per day	Price* (€/m^3)
Fixed consumption (3.5 m^3 per hh) plus 1 person's 2.5 m^3 per month (equals 6 m^3 for one occupant in a month)	0 – 0.2 m^3	0.32
Fixed consumption (3.5 m^3 per hh) plus up to 6 person's consumption at 2.5 m^3 per person per month	0.2 – 0.616 m^3	0.768
Excess consumption	More than 0.616 m^3	1.536

*Price includes sewerage charges

Furthermore, Zaragoza Municipal Council has been offering economic incentives to households that reduce their consumption rates. If households reduced their consumption by at least 40% in 2002, they were entitled to a 10% discount on the bill. In subsequent years, they were expected to reduce consumption by 10% per annum in order for them to benefit from a similar price rebate. Table 3 shows the number of households that have made water savings, and who have benefited from the economic incentives.

Table 3: Number of households benefiting from the economic incentives for water saving
(Source: Key informant, Zaragoza Finance Department, 2007).

Start Year	Households with new commitments	Further subsequent savings of 10% in the Year			
		2003	2004	2005	2006
2002	1,708	375	66	2	1
2003	27,741		5,331	487	123
2004	24,331			2,956	721
2005	27,929				4,635
2006	33,274				

The table shows that some households have the capacity to continuously make savings in subsequent years. For instance, of the 1,708 households that reduced their consumption by 40% in 2002, 375 of these made a further 10% reduction in 2003. A further 10% savings were achieved by 66 households in 2004, two households in 2005 and one household in 2006, respectively. As can be seen from column 2 of the table, the scheme is being embraced by an increasing number of households, which contributed to overall reduction in water consumption in Zaragoza described in Section 2.

4 DM Activities under the SWITCH Project

The SWITCH Project is building on achievements registered by stakeholders in the field of demand management in the City of Zaragoza. Work Package 3.1 has identified two areas through which the

SWITCH Project will add value to Zaragoza. These areas are briefly described in the proceeding sub-sections.

4.1 Enhancing Water Loss Management Strategy

Zaragoza City Council's Infrastructure Department is actively involved in replacement and rehabilitation of the water distribution network, as a way of reducing water losses in the network. The Department is also very efficient in repair of visible leaks, which have been spotted by the utility staff and customers. Following research and demonstration activities carried out by the IWA Water Loss Task Force in the past few years, it is now quite clear that most water loss is through invisible leakages, and hence effective water loss management in the distribution network requires a strategy that also encompasses pressure management and active leak management. Preliminary investigation in the City of Zaragoza has shown that there is no unit in the Infrastructure Department that is specifically responsible for active leakage monitoring and control. Therefore, Work Package 3.1 is working with the Infrastructure Department to apply an integrated approached to reduction of physical losses, as recommended by the IWA Water Loss Task Force.

We are using Actur supply area as a case study for enhanced water loss management. The population in Actur area is about 60,000 people, and four District Meter Areas have already been set up. Boundary conditions have been established, and instantaneous flow and pressure data are being logged since June 15, 2007. Arrangements are now in place to carry out zero pressure tests to verify the DMAs' integrity. The next steps are (i) to work out the leakage rates in the DMA, compare it with world figures based on the IWA's Infrastructure Leakage Index (ILI) formulae and decide whether it is economically variable to carry out leakage detection and repair; (ii) to carry out acoustic logging to localise the leaks; (iii) leak noise correlation to locate and pinpoint the leaks; and (iv) repair the leaks. We are also currently in a process of commissioning a three years' research study into innovative and advanced methods of remote and non-intrusive methods of leak detection, consumption measurement, pressure zoning, and/or how asset management could automatically be linked with water demand management.

4.2 Applying Integrated Resource Planning (IRP) to the City of Zaragoza

In the recent past, DM has been aligned within a conceptual framework of Integrated Resource Planning (IRP), a process that embraces wider strategic planning principles and fits well with integrated urban water resources management, the guiding paradigm for the SWITCH Project. 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 (White & Fane, 2001, Turner et al, 2006). IRP is based on the guiding principle that since customers of water utilities require services rather water per se, water supply systems should be designed and managed to satisfy water-related service needs or end-uses. Therefore, IRP shifts the focus of attention from the quantity of water delivered to the quality of service provided (Turner et al, 2006).

During the 1990's, significant amounts of work has been done by researchers in Australia and the US to adapt the IRP principles to the water sector. SWITCH Work Package 3.1 is adapting the IRP framework developed for water utilities in Australia (Turner et al 2006) to the water supply systems in Zaragoza. The key distinguishing features of the IRP to conventional planning is that the former requires full participation of key stakeholders; explicit consideration of local drivers in setting objectives; collection of historical data for demand forecasting; end-use analysis/modelling; levelised costing and analysis of the options based on the societal perspectives; piloting of the group of scenarios; and continuous monitoring/evaluation of the programme. We have already started the IRP

process in Zaragoza, by defining all the steps in the process and working out the roles key stakeholders will play in the process.

5 Conclusion

The severe droughts that occurred in Spain from 2001 to 2005 precipitated public action in the City of Zaragoza aimed at conserving water use in the consumers' premises, leading to reduction in the city's overall consumption of 14% between 1996 and 2004, in spite of a 6.3% increase in population. These gains in water conservation were mainly as a result of communicative and economic instruments targeted to the end-users. The SWITCH Project aims at building on these achievements by expanding the scope of the DM measures to improve efficient water use on both the utility and consumers' sides, through research and demonstration activities that contribute to the achievement of sustainable and effective urban water management schemes in the 'city of tomorrow . Furthermore, the Project will add value by taking an integrated approach to the DM activities through application of IRP concepts to Zaragoza water supply systems.

References

Arbués, F. and Villanúa, I., 2006. Potential for pricing policies in water resource management: estimation of urban residential water demand in Zaragoza, Spain, *Urban Studies*, **43**(13), 2421-2442.

Edo, V.V. and Soler, M.F., 2004. Saragossa, 50 examples of efficient water use in the city, *Water Science and Technology: Water Supply*, 4(3), 111-122.

Fundación Ecología y Desarrollo, 1998. Zaragoza, saving water city (Spain), available at http://habitat.aq.upm.es/bpes/onu98/bp439.en.html (accessed on 9 August 2007).

Fundación Ecología y Desarrollo, 2001. Zaragoza, saving water city – 50 best practices, unpublished report, Zaragoza, Spain.

Garrido, A., Iglesias, A., Garrote, L., Moneo, M., Gómez, A., Flores, F., Cubillo, F., Ibáñez, M., Fernández, M. and Lapeña, A., 2005. Spain in Iglesias A. and Moneo, A (eds), *Drought preparedness and mitigation in the Mediterranean: Analysis of the organizations and institutions*, Options Méditerranéennes: Série B. Etudes et recherches, n.51, Zaragoza, Spain.

Savenije, H. and van der Zaag, P., 2002. Water as an economic good and demand management: paradigms with pitfalls,. *Water International*, 27 (1), 98-104.

Turner, A., Willets, J., Fane, S., Guirco, D., Kazaglis, A., and White, S., 2006. *Planning our future urban water resources: A guide to demand management in the context of integrated resource planning*, Institute of Sustainable Futures, University of Technology, Sydney.

UNEP-International Environmental Technology Centre, 2003. *Integrated Urban Resources Management Strategy: Water*, UNEP, Nairobi.

UN-HABITAT, 2004. *State of the world's cities, 2004/05*, UN-HABITAT Report, Nairobi, Kenya.

UN-HABITAT, 2006. *State of the world's cities, 2006/7*, UN-HABITAT , Nairobi, Kenya.

United Nations, 2007. The Millennium Development Goals Report 2007, UN, New York.

White, S.B. and Fane, S.A., 2001. Designing Cost Effective Water Demand Management Programs in Australia, *Water Science and Technology* Vol. 46, No 6-7, pp.225-232.

Zaragoza City Council, 2006. Management and use of water in Zaragoza, unpublished departmental report, Zaragoza, Spain.