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Using economic instruments for water resources management in the city of the future: case studies from Spain and Uganda

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ABSTRACT
Rapid increase in global population coupled with escalating climate change has led to a serious water scarcity in the world. The pressure on the water resources is higher in urban areas, where, according to UN Habitat, over 50% of the world's population have lived since 2007. Hence, urban water managers and policy makers need to adopt water efficiency measures to cope with the increasing water demand and manage available water resources in a sustainable manner. This paper reports on findings of water demand management studies conducted under the EU-funded SWITCH research project on 'sustainable water management for the city of the future'. Using the case of Zaragoza City (Spain), the paper shows how a tariff structure and other economic instruments have been used to encourage water use efficiency at the end-users' premises, resulting into a 14% reduction in the city's water demand between 1996 and 2004, although the population increased by 6.3% in the same period. The study also used 2006/07 billing data from the Uganda's main urban utility to model a water conserving tariff for domestic consumers in Kampala City. Results from the model show that using a demand-responsive tariff structure, 15% of water produced in Kampala could be conserved, and the utility's revenue increased by 8%. Water conservation tariffs will have greater social equity benefits in cities of developing countries where water services may be under-priced, intermittent and unfairly distributed in favour of higher income households. Water conserved could be redistributed to the poorer settlements of the cities.

Keywords: Integrated Urban Water Resources Management, Demand Management, Economic Instruments, Tariffs, Modelling

1. NEED FOR INTEGRATED URBAN WATER RESOURCES MANAGEMENT

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 current global population is estimated to be 6.9 billion people, of which 82% live in developing countries (UN-HABITAT, 2009). 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.

The water scarcity situation will escalate in the urban areas of less developed regions where it is estimated the urban population will increase from about 2.57 billion in 2010 to 3.95 billion in 2030, accounting for 94% of the global urban population growth in the period 2010-2030 (ibid). The situation calls for the adoption of integrated water resources management (IWRM). IWRM is an approach that '…promotes the coordinated development and management of water, land and related resources, in order to maximize the resultant economic and social welfare in an equitable manner without compromising the sustainability of vital ecosystems' (GWP, 2006, p.22). The principal components of IWRM in urban areas are supply optimisation; demand management; participatory approaches to en-

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sure equitable distribution; improved policy, regulatory and institutional framework; and intersectoral approach to decision-making (UNEP-IETC, 2003). Water Demand Management (WDM), one of the components, may be defined as the development and implementation of strategies, policies and measures aimed at influencing water 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 WDM measures (ibid): 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.

The remainder of this paper describes how tariffs and other economic instruments could be used to manage water demand in the city of the future. This study was carried out as part of an integrated research project funded by the European Union (EU), whose overall objective was apply IWRM concepts for achievement of effective and sustainable urban water schemes in the 'city of the future (i.e. projected 30-50 years from now)'. The five-year SWITCH (Sustainable Water management Improves Tomorrow's City Health) project aimed at developing 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. Zaragoza, a city in Central Spain was one of the partner cities for the SWITCH project, and was a demonstration city for the research activities under the WDM work package of the project. The next section briefly discusses the use of economic instruments for water demand management. Then, we report on how tariffs and economic incentives have contributed to a successful integrated programme for enhancing water saving culture in Zaragoza City. Thereafter, we provide results of a model developed for applying an example of a more water-conserving tariff in the city of Kampala, Uganda.

2. USING ECONOMIC INSTRUMENTS FOR WATER DEMAND MANAGEMENT

The use of Economic Instruments (EIs) gained prominence in the 1970s when polluter-pays principles were first advocated for. EIs may be defined as '…the use of market-based signals to motivate desired types of decision-making. They either provide financial rewards for desired behaviour or impose costs for undesirable behaviour' (Cantin et al, 2005, p.2). The overall aim of EIs is to shift the costs of resource use or pollution control from society to end users. Use of EIs in the field of environmental management aims at modifying the behaviour and decisions of stakeholders and individuals for the promotion of environmental protection, encouraging optimal rates of resource use /depletion, and for providing financial resources to support environmentally-friendly practices (ibid).

There are two broad categories of EIs: those that use existing markets and modify the market prices of goods and services such that existing environmental impacts are considered by the users; and those that create new markets for environmental goods and services. Examples of common instruments that operate within existing markets are application of tariffs for existing services; levying of environmental taxes and charges on the degradation/pollution and/or extraction of natural resources; and provision of financial incentives and/or subsidies for good environmental practice. Use of subsidies is not as widespread in the water sector as in the agricultural sector, where subsidies are provided to increase attractiveness for 'green' products and production factors that have limited negative environmental impact. The most commonly used economic instrument for water demand management is the water tariff. Ideally the tariff should be based on full-cost pricing, to include all costs of construction (including opportunity cost of capital), operating, maintaining and replacing the infrastructure, as well as externality costs such as environmental degradation. However, not only is it difficult and challenging to take into account all the externalities, in many cases policy makers are reluctant to recover full costs from consumers, mainly for political reasons.

The use of water tariffs as economic instruments for managing water demand is made possible through application of the universal economic theory of supply and demand to water sup-

ply services. For goods in a perfect market, prices guide the choice of how much to produce and how much to consume, and serve to balance supply and demand. These conditions do not fully apply to water services: studies have shown that water consumption is not substantially affected by changes in price, especially in the short term. Water services are price elastic, i.e. changes in price induce relatively smaller changes in consumption. Consequently, the demand/supply curves for water services may not depict the profile that is typical for other goods and services. A tariff structure is said to be conservation-oriented if it encourages efficient water use and discourages wastage of the water resource. These two conditions can only be fulfilled if water bills sent to customers communicate the full cost of providing water services, including the cost of exploiting new water supplies. These tariffs should be based on marginal cost pricing and resource efficiency goals (Cantin et al, 2005). Marginal costing reflects estimates of the costs of developing the next increment of supply required to satisfy a given increase in water demand.

3. COMBINED ECONOMIC INSTRUMENTS FOR WDM IN ZARAGOZA

The city of Zaragoza, situated in the central area of the River Ebro basin, is the capital of Aragón region in North-eastern Spain. The municipality of Zaragoza has a population of about 682,300 people (2008). 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. 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: Lucea, 2010)

Consumption Range	Price (Pesetas* per m^3)
0 - 6 m^3 per property per month	12
6.1 – 13 m^3 per property per month	25
13.1 -35 m^3 per property per month	40
Over 35 m^3 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 (AYTO) initiated a long-term programme to reform the tariff in 1995, in which changes were implemented in a step-wise fashion. The tariff reform process was informed by findings of an econometric study carried out by the University of Zaragoza between1996-2004. The key findings were: (i) the average price elasticity of demand was –0.0811; (ii) the average income elasticity of demand was 0.7919; and (iii) the average elasticity of water consumption with respect to family size was 0.4794 (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. Changes were subsequently made, and tariff structures that have operated since 2005 have been designed to match the socioeconomic attributes and consumption habits of the population. Table 2 presents a 2009 tariff structure for household size of up to six, and it shows that 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

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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 poor.

Table 2: Typical 2009 Zaragoza variable water tariff (Source: Lucea, 2010)

	Rates (€m^3 of water)	
	Water	Sewerage
Block 1: Fixed consumption (3.5 m^3 per HH) plus 1 person's 2.5 m^3 per month = 6 m^3 for one occupant in a month	0.16	0.17
Block 2: Fixed consumption (3.5 m^3 per HH) plus up to 6 person's consumption at 2.5 m^3 per person per month, i.e. over 6 m^3 and up to 18.5 m^3 per HH per month	0.39	0.41
Block 3: Consumption over 18.5 m^3 per HH per month	0.78	0.82

Furthermore, AYTO has been offering economic incentives to households that reduce their consumption rates. If households reduced their consumption by at least 40% in the first year of joining the scheme, 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 benefited from the economic incentives when the scheme started in 2002, to 2006.

Table 3: Number of households benefiting from the economic incentives (Lucea, 2010).

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 had 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 was embraced by an increasing number of households, which contributed to overall reduction in water consumption in Zaragoza in subsequent years.

The economic instruments described above complemented activities carried out as part of a long-term programme implemented by a partnership of key stakeholder organisations in Zaragoza that aimed at improving the efficiency of urban water use in Zaragoza. This programme was implemented between 1997 and 2008, and used a combination of measures and instruments to cause behavioural changes among the end users and encouraged them to make structural changes in their fixtures and appliances, which resulted into the positive changes in water use efficiency. Although the city's population increased from 606,069 in 1997 to 682,283 by 2008 (an increase of over 12%), the city's overall water consumption reduced from 84.8 to 61.5 million m^3, respectively, which was a reduction in consumption of 27% (AYTO, 2009). A survey conducted in Zaragoza showed that water conservation was more as a result of behavioural change than adoption of water-efficient devices (Edo & Soler,

2004). The economic instruments applied by AYTO contributed to the behavioural change, as can be extrapolated from data shown in Table 3.

4. MODELLING A WATER-CONSERVING TARIFF FOR KAMPALA

Kampala, with an estimated daytime population of 1.35 million, is the capital city and industrial hub of Uganda, accounting for about 65% of the national economic activities. About 45% of the city residents live in low-income informal settlements, with limited infrastructural public services (Beller Consult et al, 2004). The water and sewerage services in Kampala and 21 other major urban areas in the country are provided by the National Water and Sewerage Corporation (NWSC), a corporatized public-owned utility, and currently managed under the public law. NWSC draws raw water for the Kampala water treatment plant from Lake Victoria, whose water levels have been declining at an apparently alarming rate due to recent droughts associated with climate change. The water quality has also deteriorated mainly because of unplanned human settlements at the lake shores. Therefore, NWSC has had to upgrade the raw water intake system and improve the treatment process for Kampala water supply, which project has required significant investments in the past few years. Even then, NWSC estimated that by 2006, it provided water services to 76% of the city's population (NWSC, 2006).

The objective of this study was to demonstrate how water-conserving tariffs could be used as an economic instrument to encourage current household consumers to conserve water in their premises, and hence reduce the pressure placed on the infrastructure and the water resources in Kampala. This study was conducted by developing a Microsoft Excel-based model using primary billing data for one financial year (i.e. July 2006 to June 2007). An average of 70,851 monthly household billing data sets were received from NWSC in form of Microsoft Access database, which comprised of billing data for only the category of household connections. These datasets were converted into an SPSS data set, and then examined to eliminate data corresponding to inactive accounts (i.e. disconnected from service either due to non-payment or technical faults), properties with incomplete entries, and entries with negative/zero consumption and/or billings. The remaining data translated to 54,024 household properties, arranged in a hierarchical order based on the customer reference numbers. Using SPSS, a five percent random sample was drawn, giving a total of 2,701 household properties.

Studies on price elasticity of demand are quite rare in developing countries, and no such studies have been done in Kampala. Since price elasticity of demand is an important input into a model for pricing decisions, a literature search was conducted to identify a city with similar characteristics where price/demand studies had been conducted. The closest match for the parallel surveying method was the City of Cape Town, whose price elasticity estimated figures were reported in a study by Jansen og and Shulz (2006). The study also adopted socio-economic attributes for Kampala obtained through recent studies conducted, as listed below:

- Average household size of 5 obtained from the Uganda National Household Survey 2005/2006 (UBOS, 2006);
- Per capita water consumption estimates for three income categories (high, medium and low) obtained from a consultancy study by Beller Consult et al (2004).
- Estimated (2004) income ranges for customers of NWSC in Kampala, obtained from a study on water service connection charges and costs (Kayaga and Franceys, 2007) and adjusted by Uganda's national economic growth rate of 6%.

Table 4 shows socio-economic data obtained from these studies, which were matched with the price elasticity of demand figures obtained by parallel surveying with Cape Town, and used as inputs into the pricing model. The following key assumptions were taken into consideration: (i) each household uses its own water service connection, with no sharing between the households; (ii) the average household size is the same across the income categories in Uganda's urban areas (i.e. 5 people per household); (iii) domestic water use patterns remain the same over the modelling period; (iv) annual price adjustments of 6%, indexed to inflation rates have negligible effect on demand for water; and (v) Affordability to pay for water services conform to the World Bank's rule of thumb of not more than 3% of the household income.

Table 4: Model inputs derived from recent studies in Kampala and Cape Town (Motoma, 2007)

Income Category	Estimated Income ('000 UGX)	Average per capita consumption (litres)	Monthly Household consumption (m^3)	Estimated Price Elasticity of Demand
High Income	> 1,403	144	> 22	-0.23
Middle Income	503– 1,403	100	11 - 22	-0.32
Low Income	< 503	40	< 11	-0.99

The model, which optimised the price levels for different income groups according to the affordability criteria (above), was based on the following equation for Price Elasticity of Demand:

$$Q_2 = \left\{ 1 + \left(P_2 / P_1 - 1 \right) \times E_d \right\} \times Q_1$$

(1)

Where Q_1 is the initial quantity of water consumed, when the price is P_1; Q_2 is the adjusted quantity consumed when the price is changed to P_2. At the time of the study, NWSC charged a uniform rate of Uganda Shs 1,213 per cubic metre for all household consumption (i.e. P_1 = 1,213 for all the three categories).

Table 5: Outputs of the Tariff Model (Source: Motoma, 2007)

	Block 1	Block 2	Block 3	Average
Price (Uganda Shs/m^3)	1,190	1,372	1,914	1,314
Percentage change in tariff	-2%	13%	58%	8%
% Change in per capita consumption	0	+4%	-53%	-20%
Change in consumption (m^3/year)	-15,812	1,246,152	3,765,414	
Proportion of households	29%	49%	22%	
Water allocation	14%	48%	38%	

Table 5 shows key changes in consumption patterns that would be imposed by the new increasing block tariff provided by the model. Based on the affordability criteria of 3% of household income, higher rates for the second and third blocks of consumption are derived through the model, while the price for the first block has been reduced, which tariff structure would encourage water conservation. The table shows that whereas per capita consumption rates for block 3 would reduce by 21% as a result of the price increase, per capita consumption rates in blocks 1 and 2 would not change significantly. Similarly, the proportion of households in the high consumption block would reduce from 39% to 22%. This tariff structure would enhance allocative efficiency, given that water consumed by the high income group would reduce from 55% to 39%. Furthermore, use of this tariff structure would result into overall water savings worth 2,535,074 m^3 while increasing revenue collection for the utility by 1.7 billion Uganda Shillings per year. The water savings made could be utilised to expand services to low-income unplanned settlements in Kampala, where most households are not directly connected onto the City's water reticulation network, partly due to inadequate water in the supply system (NWSC). Densification of connections in low-income settlements, removing 'barriers to entry' in the connection

process and recognising group connections would reduce the negative effect an increasing block tariff to the urban poor.

5. CONCLUSION
WDM strategies could be used in the short term to plug the supply-demand deficits currently existing in many cities of developing countries, and promote sustainable urban water management in the city of the future. This paper reports on case studies conducted in Zaragoza and Kampala on the use of economic instruments for WDM. Water conservation tariffs have greater potential benefits in cities of developing countries where water services are excessively underpriced. The effectiveness of tariffs and other economic instruments for water demand management depends on optimally aligning them with the socio-economic status of the consumers. Two key lessons may be drawn from these case studies. Firstly, economic instruments will make a significant contribution to water conservation only if implemented in combination with other water demand management measures. Secondly, there is need to carry out research and accurately map the socio-economic status of the consumers so as to design effective economic instruments.

6. ACKNOWLEDGEMENTS

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