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Using tariff structures as a demand management instrument: The case of Kampala

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Urban population explosions in developing countries, compounded by impacts of climate change have resulted into urban water infrastructure services being placed under a lot of pressure. In response, urban water managers and policy makers should consider water demand management strategies, in addition to supply options. This study used data from recent studies in Uganda and parallel surveying findings from the city of Cape Town to model a water conserving tariff for domestic consumers in the city of Kampala, Uganda. Results from the model show that 15% of water produced in Kampala could be conserved, and the utility's revenue increased by 8%, through demand-responsive tariffs. Water conservation tariffs may have greater potential benefits in cities of developing countries where water services are excessively under-priced.

Need for water demand management

The global population has continued to increase rapidly, with developing countries making the largest contribution. The world population was estimated to be 6.7 billion in 2007, 5.4 billion of whom lived in the less developed regions (United Nations, 2007). This population increase has serious implications on water resources management, as per capita water availability is steadily declining. The water scarcity situation is compounded by the major impacts of climate change on the water resources, namely shorter duration of the precipitation seasons and increase in hydrological extremes.

The water scarcity situation will get worse in the world's urban areas where, it is projected, there will be a population increase of 2.12 billion between 2000 and 2030, with over 95% of this increase expected to be in low-income countries (UN-HABITAT, 2004). There is a need, therefore for policy makers and professionals in the urban water sector to rethink the way they manage water resources. Instead of focusing on only supply-side options, there is need to also apply water demand management (WDM) measures both at the utility and end-user sides. WDM has been described as the development and implementation of strategies aimed at influencing demand patterns so as to achieve efficient and sustainable use of water (Turner et al, 2007). For WDM to be sustainable, utilities need to tap into the conservation potential from both behavioural and technical categories and use a combination of measures and instruments that will achieve the optimum changes. Measures are actions to be taken, e.g. conversion of inefficient to efficient flush toilets. Instruments are used to ensure the chosen measures are taken up by the customers, and may be categorised as regulatory, communicative or economic (ibid, 2007). The next section looks in more details at use of water tariffs as one of economic instruments for WDM.

Water tariffs as a WDM instrument

Setting water tariffs is an important function for a water utility, as water pricing may be used to achieve several objectives. One important objective for water pricing is ensuring revenue collection for cost recovery. Revenue collection may also cover appropriate return on capital employed. Another key objective could be using the tariff to allocate social benefits through equitable distribution of revenues collected from different income groups in line with their affordability-to-pay. Water prices may also encourage efficient water use, although the utilities may not have necessarily designed the tariffs with demand management objectives in mind. However, it is important to note that some uses of water will not substantially be affected by changes in price. In order to fully understand the role of tariffs in water demand management, it is useful to internalise the price elasticity of demand properties of various levels of water usage.

Price elasticity of demand (E_d) may be defined as the ratio of the percentage change in quantity demanded to the percentage change in price (Case and Fair, 1989). Since the relationship between the price and the quantity demanded is usually negative, E_d is also negative, but its absolute value is usually quoted in the literature. When the change in quantity demanded is higher compared to the price change, demand for that good or service is said to be elastic, i.e. less than one. On the other hand, if changes in price induce relatively small changes in consumption, economists label that demand as price inelastic. Water used for domestic chores such as drinking, cooking, washing utensils and sanitation/personal hygiene has been observed to be price inelastic, mainly because potable water has no close substitutes to which consumers can switch. Water for other purposes has limited substitutes, and is more price elastic. Therefore, while applying general demand-supply economic laws to water services, it is important to identify the different elasticity properties applying to various end uses, and obtain averages over the range (California Urban Water Conservation Council [CUWCC], 1997).

Utilities may fix their tariff based on either historical costs or marginal costs. Historical costs represent the costs actually incurred by a utility in providing the service, and such costs signal consumers about the past cost consequences of usage decisions. On the other hand, prices based on incremental or marginal costs provide signals to consumers about future cost consequences of their usage decisions, and reflect an estimate of the costs of developing the next increment of supply required to satisfy additional demand. Economists generally consider marginal cost pricing to provide better price signals in terms of achieving efficiency in supplying and using the water resources (CUWCC, 1997). Such price signals provide a basis for consumers to make informed decisions about how to use water efficiently.

Although many utilities in developing countries have attempted to set up economic tariffs, most of these measures have not been specifically carried out as part of WDM strategies. This paper describes a study that was carried out in Kampala (Uganda) whose overall purpose was to evaluate the use of a water tariff as an economic instrument for WDM. This study was carried out by the second author in 2007, in partial fulfilment of the requirements of the MSc degree of Loughborough University (Motoma, 2007).

Study setting, objectives and methodology

Kampala, with an estimated 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, Mott MacDonald and M&E Associates, 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 alarming rate due to recent droughts associated with climate change. The water quality has also deteriorated 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 demand-responsive tariffs could be used as an economic instrument with existing customers to encourage them to conserve water, 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 data 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 as per 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 and Associates (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 1 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.

Table 1. Model inputs derived from recent studies in Kampala and Cape Town (Motoma, 2007)

Income Category	Data From Kampala Studies			Data from Cape Town
	Estimated Income (Uganda Shillings)	Average per capita consumption (litres)	Monthly Household consumption (m3)	Est. Average Price Elasticity of Demand
High Income	> 1,403,000	144	> 20	0.99
Middle Income	503,000 – 1,403,000	100	11 - 20	0.32
Low Income	< 503,000	40	< 11	0.23

The following key assumptions were taken into consideration:

- Each household uses its own water service connection, with no sharing between the households;
- The average household size is the same across the income categories (i.e. 5 people per household);
- Domestic water use patterns remain the same over the modelling period;
- Annual price adjustments of 6%, indexed to inflation rates have negligible effect on demand for water;
- Affordability to pay for water services conform to the World Bank's rule of thumb of not more than 3% of the household income.

The model was based on the following equation for Price Elasticity of Demand, E_d:

$$Q_2 = \left\{1 + \left(P_2 / P_1 - 1\right) x \; E_d\right\} \; x \; Q_1$$ ....[Chestnutt et al, 1997]

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 = 1,232 for all the three categories).

Results and discussion

The model came up with an increasing block tariff that provided higher rates for the second and third blocks of consumption, in order to encourage water conservation. However, based on the adopted price elasticity of demand, the price for the first block should be reduced. Table 2 shows key changes in consumption patterns imposed by the new tariff regime. The table shows that whereas average 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. This is an expected result, since E_d for the first two blocks is highly inelastic. As a result in the price increase for block 3, the proportion of households in the high consumption block would reduce from 39% to 22%, a few of them having to revert to block 2.

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 by 1.7 billion Uganda Shillings (an increase of 8%). This result is in line with the economic principles which state that when demand is price-inelastic, price increases will lead to increase in revenue; while price reduction will lead to loss in revenue . As can be seen all the consumption blocks have been assumed to have price elasticity of demand $E_d < 1$ (i.e. inelastic). 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, 2006).

Table 2. Outputs of the Tariff Model

	Block 1 (Low)	Block 3 (Middle)	Block 3 (High)	Average
New Price (Uganda Shs/m^3)	1,190	1,372	1,914	1,314
Consumption (m3 per h-hold per month)	0-11	11-20	>20	
Percentage change in tariff	-2%	13%	58%	8%
% change in per capita consumption	0	+4%	-53%	-20%
Change in consumption (m3/year)	-15,812	1,246,152	-3,765,414	
Proportion of households	29%	49%	22%	
Water allocation	14%	48%	38%	

Conclusion

WDM strategies could be used in the short term to plug the supply-demand deficits currently existing in many cities of developing countries. This paper reports on a case study conducted in Kampala on use of tariffs as an economic instrument for WDM. Through simple modelling, based on the assumption that price elasticity of demand for water is similar to the one depicted by residents of Cape Town (South Africa), it has been shown that 15% of water supplied in Kampala could be conserved, and the utility's revenues increased by 8%, through demand-responsive tariffs. Water conservation tariffs have greater potential benefits in cities of developing countries where water services are excessively under-priced.

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