The effect of tariff on water demand management: implications for Bahrain

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Abstract Water is now considered a scarce but essential resource that should be managed in an integrated manner. The traditional approaches of resource development are now considered as unsustainable. Water demand management (WDM) is a new approach that aims at influencing demand & thus improving distribution efficiency. Economic measure through water tariff is one of the WDM tools. Water tariffs are recognized to be one way of curbing growth in water demand, and encouraging more efficient use of water. It is essential for the effective and equitable allocation of water resources. This paper investigates different water tariff structures & seeks to identify the factors affecting WDM through tariffs. The paper pays particular attention to the situation in Bahrain through preliminary exploration of price elasticity of demand for water and its comparison with figures from other countries.

Keywords Bahrain; tariff; tariff structure; water demand management; water price elasticity for demand

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Introduction

Bahrain is located in arid region and characterized by a harsh desert environment with no surface water (rivers or lakes).Water is a scarce resource in Bahrain, and supplies are severely limited.

Bahrain relies on desalination and reclaimed wastewater to supply bulk municipal and industrial water. Due to the increase in population the reliance on this mode of water supply will continue. Bahrain is already consuming over 100% of its renewable water resources. In Bahrain the cost of producing water is very high while the water tariff is very low. This means no incentive exists under present tariff policies for consumers to save water which is highly subsidised (75%) by government. The imbalance between water demand and the limited water resources is increasing due to high standard of living and increase in population (2.5%). Non Revenue Water (NRW) in Bahrain (currently at 367.08 m^3/connection/ annum, 28.87%) is relatively high compared to other countries.

Over the years, the precious natural water resources were exploited in order to meet increasing demand, and desalination technology was introduced and developed rapidly to satisfy the water needs of growing demand and also an alternative towards ground water overexploitation as new natural water supply sources have become less accessible, and less acceptable environmentally (high salinity), managing demand have taken an increasing importance. Therefore, there is an urgent need to switch over to a new paradigm that takes a holistic view of water availability and demand from the traditional management practices of water resources (Ismail and Al-Maskati, 2002; Hashim and Hajjaj, 2002).

The focus of this paper is limited to an initial, preliminary exploration of price elasticity of demand for water figures obtained from various countries. A more detailed study of this topic taking into consideration customer survey (contingent survey) is also planned. It looks at current water tariff applied in Bahrain and compares current water

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tariffs applied in Bahrain with GCC countries and recommends a proper and effective water tariff reform or structure.

Water demand management principles and categories

Water consumption can be affected by technical, educational, institutional or economic instruments and tools, or a combination of these. Technical categories include interruptions to supply or pressure control by reduced pumping or flow control in pipes. Educational/behavioural methods include public appeals, changes in water-use habits or use of legal instruments. Institutional/regulatory categories include building and plumbing codes, economic categories include well designed water tariff system Incentives for water conservation.

It has been demonstrated in many countries that saving water rather than the development of new sources is often the best, wise and "next" source of water, both from an economic and environmental point of view. Water Demand Management (WDM), therefore, is seen as the preferred alternative to meet increasing water demand in many countries. WDM can be defined as a strategy to improve efficiency and sustainable use of water resources taking into account economic, social and environmental considerations (Schuringa, 2000). It differs from supply management that it targets the water user rather than the supply of water to achieve more desirable allocation and sustainable use of water. WDM has many instruments among which the one stated above and listed in Table 1.

Work on water demand management is an ongoing process, some relevant examples are:

- WDM works in the Middle East and North Africa (MENA), Israel include public awareness and education programs, conservation, leak detection, waste water reuse in irrigation, and recycling (Abu Qdais, 2004 and Arlosoroff, 2004).
- In Canada, work on WDM covers augmentation of the database such as education to promote water conservation, rebate programs, and watering restrictions.
- In Australia, WDM options include leak detection and repair, price reform, regulation of performance of water using appliances (White, 2001).

Tariff as a water demand management tool

Setting water tariffs is one the most controversial water demand management tools. Implementing water pricing as a water demand management tool requires not only an understanding of the full spectrum of urban issues, but also institutions to ensure that those charged with reforms are able and willing to carry them out. Usually such issue might be integrated with social and political plus human resources interventions.

Table 1 Price elasticity of demand for water estimates for different purpose from different studies

Study	Location	Description	ED
Howe & Linaweaver (1967)	USA	Indoor Demand	0.23
		Outdoor use-wet areas	1.6
Pope (1975)	US 4 cities	Domestic	0.182 – 0.5
Grima (1972)	Toronto	Domestic winter use	0.75 – 1.07
OECD (1987)	OECD	Domestic	0.005 – 0.3
UK Joint Study	UK	Outdoor use	1
		Indoor use	0.2
Thomas & Syme (1979)	Perth	Indoor use	0.04
	Australia	Outdoor use	0.31
Veck and Bill (1998)	Alberton	Indoor use	0.13
	S/Africa	Outdoor use	0.38

Source: Lecture notes on price elasticity, Loughborough University, 2007

Establishing an appropriate pricing structure for water supply is one of the most important tasks in a demand management strategy. It promotes the use of pricing as an incentive for consumers to use water resources in a more sustainable manner and to recover the cost of water services per sector of the economy. Low water tariff, discourage water conservation, but if tariff was adequate and provides a price signalling mechanism, consumers will be more careful about the water they are using. Therefore water tariff should be set in such away where all people of all income can afford sufficient quantity of water for their basic needs and lifeline tariff should be within 3–5% of household income as suggested by Kayaga (2003) and Baumann *et al.* (1998).

Applying economic principle is a convenient way to evaluate the impact of pricing policy which includes price elasticity and cost recovery approach using marginal and opportunity cost concepts. (Module 10, ESCWA workshop, United Nations, 2005).

Water tariff can be classified into two basic types of tariff structure volumetric and non-volumetric methods. According to Boland and Whittington (2000) the most commonly used are: types of water pricing are defined as follows:

Flat Rate/fixed rate/uniform rate: is a fixed payment per unit of time for unlimited volume of water for all consumer categories. It is the most popular system for consumers.

Volume Based: The consumer is charged proportional to the measured amount or volume of water used.

Block tariffs: The block based type of tariff has two methods that are the Decreased Block Tariff (DBT) and Increased Block Tariff (IBT). In this type water consumption is divided into blocks representing ranges, and rates vary according to the volume consumed. Larger consumers pay higher rates under (IBT) or lower rates under (DBT) than smaller consumers per unit volume.

Seasonal Water and Time of Use tariffs are set according to water demands and weather conditions. In this type IBT is applied only during the summer months, (AWWA, 2005).

Price elasticity of demand ED

The effectiveness of price increases to provide economic incentives to conserve water is determined by the price elasticity of demand. When the tariff of water reflects its true cost, the resource will be put to its most valuable uses (Abu-Madi, 2004). Elasticity simply describes the percent change in water demand relative to change in price. Many researchers have investigated the relationship between the tariff of water and the consumption level. According to Abu-Madi (2004), several cases of increasing the tariff of water have demonstrated a fall in consumption. In Israel, for example, a gradual 50% drop in freshwater use was reported after a series of tariff increases. In Athens, raising the tariff of water on an increasing-block basis resulted in a monthly water consumption decline by 12–25% in 3–4 months following the introduction of the new price (Abu-Madi, 2004 quoting from Briassoulis, 1995).

The price elasticity of demand for water is price elasticity; which is defined as the percentage change in quantity taken if price is changed 1 percent, and is normally negative because the demand curve is downward sloping, which means that an increase (decrease) in price is expected to lead to a reduction (increase) in demand. For example if $ED < 1$, demand is "inelastic". This means that relative change in quantity demanded (dQ/Q) is, in this case, smaller than the relative change in price (dP/P). While if $ED > 1$, demand is elastic. This means that percentage change in quantity demanded is larger than the percentage change in price.

This equation is not appropriate to apply for the water sector as a whole, but for certain sub-sectors (e.g., urban water use, industrial water use, irrigation) it may serve the purpose of analysing the impacts of tariff changes on water consumption. The problem with the equation is that ED is not a constant. It depends on the price, on the water use and it varies over time.

Within the municipal sector elasticity varies depending upon whether the water is used indoor or outdoors, and whether the use occurs in summer and winter. Outdoor uses in summer is relatively highly elastic, since most water used for watering lawns, filling swimming pools and washing cars which are considered non-essential activities. On the other hand, indoor use is more difficult to reduce, since most water is used for essential activities such as drinking, cooking, and bathing. Such uses are not likely to change regardless of the price (Abu Qdais and Al Nassay, 2001).

For basic needs, demand is relatively inelastic or rigid. In urban water supply, elasticities are therefore generally close to zero. Poor consumers often only can afford to use small amounts of water (the basic), and any increase in tariffs will have a little effect because they cannot do with less water. For large consumers (the ones that irrigate their gardens, own cars that need to be washed, etc.) the ability to pay is such that the need to save money on water is limited. That means in this case, awareness campaigns, regulation, leak detection, etc. are often more effective than the price mechanism per sector. The IBT system is accepted as achieving the best compromise between efficiency and equity for domestic water supply by many utilities. It prices the highest value use (the most essential requirements such as drinking and cooking) lowest (first block at "lifeline" tariff), and the lowest value use (less essential uses such as a washing a car) highest (Savenije and Zaag, 2002).

Young (1996) states that "the price elasticity of demand for water measures the willingness of consumers to give up water use in the face of rising price, or conversely, the tendency to use more as price falls." Two different ways have been followed to formulate the price elasticity of demand for water: one based upon average price and the other based upon the marginal price. Agthe and Billings (1980) state that the elasticity determined based upon average price overestimates the results, and recommend that the marginal price to be used.

In studies reviewed by Brookshire *et al.* (2002), price elasticity ranged from −0.11 to −1.588 with an average of −0.49, in a review by Espey *et al.* (1997) found that 75% of the price elasticity estimates reported ranged between −0.02 and −0.75. Both of these ranges are consistent with similar lists compiled by Bauman *et al.* (1998), in general these ranges indicate inelastic demand.

Table 1 is a summary of some of the values of price elasticity of water demand reported in the literature. The use of the price elasticity of water has been applied to some cities with some important achievements have been obtained.

Table 2 compares the average water use per capita and price per cubic meter among selected Organisation for Economic Cooperation and Development (OECD) countries and GCC countries. The lowest per capita use rate shown in Table 2, as well as the highest prices, are found in the countries of north Europe. Highest average use rates are found in North America, and the prices there are among the lowest. Table 2 shows that while prices apply strong effect on consumption, they are not the only factor. Furthermore, if we compare the water charges and per capita consumption between GCC countries and OECD countries, GCC countries have high per capita consumption and low tariff. The high PCC in GCC countries could be due to low tariff, leakage, wasteful of water and also due to hot weather, therefore they consumer more water than the OECD countries.

Table 2 Water use and rates in selected organisation for economic cooperation and development countries

Countries	Estimated per capita water use (1/c/d)	Unit cost ($/m^3)
Australia	268	1.7
France	1.56	3.1
Sweden	191	2.6
Italy	213	0.84
Spain	237	1.07
United Kingdom	141	2.2
Germany	129	1.69
Japan	278	2.1
Canada	326	0.7
USA	520	1.3
Bahrain	440	not applicable
Qatar	445	1.21
Kuwait	488	0.57
Oman	203	not applicable
Saudi Arabia	300	not applicable

Source: data compiled by author, 2006

Bahrain – changes in tariff, and effects, since 1986

Bahrain MEW has adopted rate structure tariff that charge consumers according to the Sectors & the amount of water consumed. In Bahrain, water tariffs are substantially lower than the actual production costs. The government heavily subsidises the domestic and, to a lesser extent, the industrial supply.

The average water production cost in Bahrain is 0.77 $/m^{3}and after adding the distribution cost to the domestic sector total cost arrives at 1.05 $/m^3 (MEW, 2005). Water tariff for domestic sector large block (101 m^3 and above) is only charged at 0.56 $/m^3 which is well below the total cost of 1.05 $/m^3(MEW, 2005). This means that in the case of highest consumption block for domestic supplies, the charges do not cover water production and distribution costs. That means the country is not only subsidizing lower block (1–60 m^3/month) consumers (consumers who are economical in their use of water) but the current tariff also subsidises the large block consumers who are more wasteful in their use of water. Analyzing the above facts it can easily be found that there is a huge gap between the cost of production and tariff. Only 25% of what is actually spent on producing water is received as revenue while the balance (approximately 75%) is borne by the government.

Up to the year 1983 there was a flat rate tariff of BD 0.800. In 1983, this flat rate tariff was modified by the Ministerial Resolution No. 13 (1983), which set the flat rate at BD 1.500.

First incremental water tariff was imposed in Bahrain in 1985 by the Ministerial Resolution No. 3 (1985). This tariff structure was modified and strengthened by the Ministerial Resolution No. 14 (1985) and later by the Ministerial Resolution No. 19 (1986).

In 1992 tariff structure was again revised under Ministerial Resolution No. 2 (1992) and is currently in force. Relevant details regarding each tariff structure are listed in the Table 3 below.

In setting up water tariffs for Bahrain in the domestic sector, "lifeline rate schedule" for water has been adopted which does not encourage water conservation. This system includes a very low block rate for small water consumers, incrementally increasing to a higher rate for large consumers, using a scale of block tariffs referred to as the incremental increase tariff. Table 4 present the current water tariff in Bahrain for different sectors.

Comparison of water tariff in Bahrain and other GCC countries

Following from previous section, Bahrain practices increasing block tariff for water charges only as sewerages charges go to the municipality; it is basically to recover some

Table 3 Water tariff structure in Bahrain during 1985 – 1992

Year	Type of tariff	Consumption	Tariff/m³	Remarks
1985	domestic	001–45	45 fils (0.125$)	Applied from 1st April 1985
		46–65	110 fils (0.308$)	
		66 and above	450 fils (1.26$)	
	non domestic	001–450	450 fils (1.26$)	Applied from 1st April 1985
1985–1986	domestic	001–50	45 fils (0.125$)	Applied from 1st Sep 1985 to 1986
		51–100	110 fils (0.308$)	
		101–150	200 fils (0.56$)	
		151 and above	450 fils (1.26$)	
	non domestic	001–450	450 fils (1.26$)	No change in non domestic tariff since 1985
		451 and above	770 fils (2.156$)	
1986–1992	domestic	001–50	45 fils (0.125$)	Applied from November 1986 to April 1992
		51–100	110 fils (0.308$)	
		101 and above	200 fils (0.56$)	
	non domestic	001–450	300 fils (0.84$)	Applied from November 1986
		451 and above	400 fils (1.12$)	
1992	domestic	001–60	25 fils (0.07$)	Applied from 1st May 1992
		61–100	80 fils (0.21$)	
		101 and above	200 fils (0.56$)	
	non domestic	001–450	300 fils (0.84$)	Applied from November 1986
		451 and above	400 fils (1.12$)	

Source: Ministry of Electricity and Water, Bahrain, 2005

of the cost of water production and distribution through it. But it is highly subsidised beside being used as a water conservation tool.

The installation of water meters began in 1986 and billing on the basis of metered consumption commenced in 1990, but data from billing system for consumption by customer categories was only available from 1993; the system has been developed by customer services for billing and revenue collection purpose and thus is not ideally suited to analysis consumption.

Although the progressive block tariff system is a very good instrument for water demand management, the system can have negative effects if the aim is to subsidize water requirements and the subsidy is generally affordable.

In the GCC countries, production costs range between US$ 1.1/m^3 and US$ 2.0/m^3, except for the lower costs in Bahrain (US$ 0.065/m^3) where groundwater is blended with desalinated water using a ratio of about 1:3, respectively, for drinking use. More importantly, the gap between production costs (including production, transmission, and distribution) and revenues is quite large in all GCC countries, resulting in large subsidies portion ranging between US$ 0.5/m^3 and US$ 1.8/m^3 (ESCWA, 2005).

Table 4 Water tariff for blended water in Bahrain

Range in m³/ month	Cost in US$/m³
Domestic Sector	
1–60	0.07
61–100	0.21
101-and above	0.53
Commercial and Industrial	
1–450	0.8
451-and above	1.06

Source: Customer Services Directorate, MEW, 2005

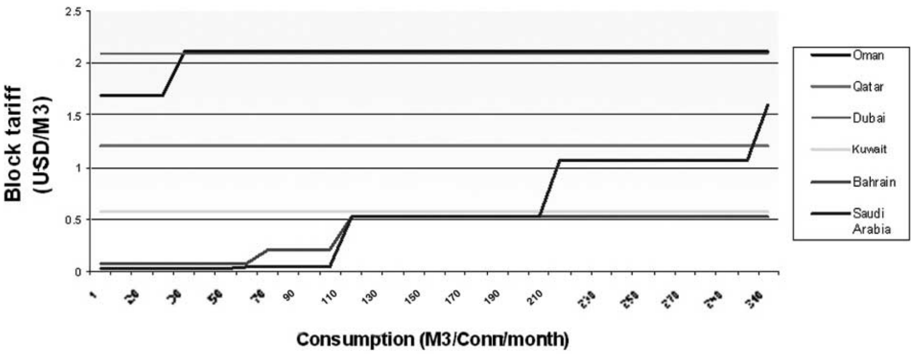

Figure 1 Block tariff for water–GCC countries. Source: data gathered by author from different GCC ministries

Although Bahrain has employed a progressive tariff system since 1990, per capita consumption is high due to the rate itself being very low.

Bahrain, Oman and Saudi Arab have adopted progressive block tariff system, whereas Kuwait, the UAE and Qatar have retained flat rate system. Qatar and the UAE exempt their national citizens from municipal water charges, therefore the actual cost recovery rates have lower than normal tariff rates. Figure 1 shows Block Tariffs for water in GCC countries.

Findings

Price elasticity of demand is important in restructure of water tariff. But due to unavailability of accurate data it was difficult to calculate price elasticity of demand for Bahrain for the domestic sector due to the use of the increasing block tariff structure and we could not segregate water consumption for each block. Water is highly subsidised by the government in GCC countries and PCC is higher than developed countries.

Conclusions and recommendations

There seems to be no clear procedure to calculate the elasticity: some use average price, while some use marginal price and still some include the intra-marginal rate structure. Estimating elasticity of demand under uniform rate structure is relatively straightforward. However, this task is more difficult when more complex rate structures (i.e. IBT and DBT structure) are employed. Residential water consumers respond to changes and demand for water is inelastic (i.e. its absolute value is less than 1 and significant).

Price elasticity of water demand for Bahrain needs to be calculated based on contingent survey.

Tariff and recovery rates continue to remain critical issues in all developing countries. There is general political resistance to tariff increase and in maintaining tariff levels in real terms.

Tariff structure should be sufficient to cover O&M costs, and development plans while at the same time providing low lifeline rate for low consumption and penalty rate for higher consumption.

Water tariff in Bahrain needs to be reformed and give more incentive to encourage consumers to conserve water.

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