A Proposal for Water Pricing in Kuwait

Milan Milutinovic[1], Katharine A. Murtaugh[2], and Elfatih A. B. Eltahir[3]

[1] Student of Civil and Environmental Engineering, Massachusetts Institute of Technology, 77 Massachusetts Ave., Cambridge, MA 03126.
[2] Student of Civil and Environmental Engineering, Massachusetts Institute of Technology, 77 Massachusetts Ave., Cambridge, MA 03126.
[3] Professor of Civil and Environmental Engineering, Massachusetts Institute of Technology, 48-207, 77 Massachusetts Ave., Cambridge, MA 03126. Phone: (617) 253-6596. Fax: (617) 253-7462. Email: Eltahir@mit.edu.

Abstract:

Kuwait is an arid country with limited natural water resources. Yet water consumption per capita is around 450L/capita/day, which is much higher than in many other countries in the world. Certainly one of the reasons for the high level of consumption is the fact that even though water has a pricing schedule in Kuwait, water bills are not collected efficiently. Consequently, some water is wasted. The main objective of this paper is to study the potential impact of pricing as a tool for managing water demand in Kuwait. Due to a lack of empirical data regarding household consumption characteristics and price influences on demand, a demand model for Kuwait could not be constructed directly. Instead, water demand models described in the literature were adapted to Kuwait. A pricing schedule is proposed that consists of a free allowance followed by a constant water price. This proposal has the following logic: conditionally speaking, if water is consumed "reasonably", it should be free. However, to limit over-consumption, water used beyond the amount of the allowance is priced. Our results indicate that this pricing schedule would be efficient in reducing demand significantly. The model results suggest that a price of $1/m^3 for water use in excess of a 150L/capita/day allowance would reduce the demand by about one third, with a range between 20 and 40 percent depending on the model used.

1. Introduction

Kuwait is an arid country, rich in oil resources, but poor in natural water resources**.** The average annual rainfall is only about 110 mm, and because of the high potential evaporation rate and other factors, surface runoff and groundwater recharge from rainfall are rare .

The water resources in Kuwait are groundwater, desalinated water and treated wastewater. The groundwater is mostly brackish and is not used in a sustainable way, since the extraction rate is significantly greater that the natural recharge rate. The annual groundwater production in 1999 was around 118 million m^3, while under steady-state conditions, the recharge (lateral flow from Saudi Arabia) was estimated to be 44 million m^3/year (Fadlelmawla and Al-Otaibi, 2005).

Kuwait gets most of its potable water from desalination. Multi-Stage Flash is the dominant desalting technology. The desalination capacity of Kuwait is 1.65 million m^3/day (Hamoda, 2001), while the estimated cost to produce water is about $3/$m^3$. This cost estimate was calculated based on energy cost of 1.32 $/$m^3$ to produce water, and on an assumption that energy costs constitute 45% of the total desalination cost (Darwish and Al-Najem, 2005). This energy cost would roughly correspond to an oil price of $40/barrel.

The water consumption in Kuwait is around 453 L/capita/day (Darwish and Al-Najem, 2005). When this consumption is compared with other countries (California 333 L/capita/day; France 164 L/capita/day; Germany 127 L/capita/day (OECD1999, EWA 2005 yearbook)), a need to decrease water consumption in Kuwait is evident.

The main purpose of this study is to analyze the potential impact of pricing as a tool for managing water consumption in Kuwait. There may be several reasons for the large consumption, including pipeline leakage and the hot, dry climate; but one important reason is certainly the low cost of water to consumers. Water does have a pricing schedule in Kuwait, but in reality the water bills are not collected (probably because it is not politically attractive). The total income from selling 455 million m^3 of desalinated water (Kuwait's annual production) was $86 million in 2002 (Darwish et al. 2005). The annual government subsidy was $715 M in 2003.

It is known from the literature and from the experience of water utilities that water consumption shows certain elasticity to price increases (Dalhuisen et al. 2003). The original idea for this study was to construct a water demand model for Kuwait in order to quantify the influence of pricing on water consumption. However, assembling a model requires data regarding household consumption characteristics and the influence that price increases have on demand. This data is not available since household water consumption is generally not metered and because there has not been a price increase in recent years. Instead, a study was carried out using water demand models reported in the literature after recalibrating them for Kuwait conditions. Five models were used based on similar studies in other arid regions: California, Tunis, South Australia, Saudi Arabia, and Spain.

A number of simulations were performed in order to analyze the influence of various pricing schedules on the overall water demand. The schedules included constant prices, block tariffs, and a free allowance followed by various pricing schemes. In this paper, results are presented for constant price schedules with and without an initial allowance.

A pricing schedule is proposed that consists of a free allowance (e.g. 150 L/capita/day), followed by a constant price rate for additional water (Figure 1). This pricing schedule has two parameters: the allowance and the constant price. It was concluded that this pricing schedule would be economically and politically acceptable for Kuwait, and that it would help eliminate some of the waste of water. Basically, if water is consumed reasonably, the government will provide it freely. However, consumption of water beyond what is judged by society to be necessary should be priced.

An important question is how should the free allowance (eg 150 L/capita/day) be determined? One technical approach is is to use the average consumption rate in rich countries where water conservation efforts has been successful (Germany with a consumption level of 150 L/capita/day). However, as indicated above, the authors of this study believe that the collective judgment of the society through the political process should determine the magnitude of the allowance.

2. Literature Review

Water demand reduction due to price increases has been extensively studied. Most of the demand models are regression models. Typically, the demand is derived as a function of price variables and factors such as income, household characteristics, and weather.

The most common question in the literature has been which price variable to use. A consensus has not been reached about whether to use the average price or the marginal price combined with some other variables. A reasonable assumption supported by some researchers (Nieswiadomy 1992, Shin 1985) is that if consumers think their water bill is significant, they will put in the effort to learn about the exact pricing schedule and their exact consumption and hence will be influenced by the marginal price. Otherwise, where the water bill represents a small percentage of income, the consumer will react to the average price.

All reviewed studies find that household income is a significant variable that increases demand. Also, household size is frequently used in the demand equation (Nieswiadomy 1992, Renwick et al 1998, Dandy et al. 1997). Variables such as lot sizes (Dandy et al. 1997, Renwick et al. 1998, Lyman 1992, etc.), density of households, number of faucets (Renwick et al. 1998), and age distribution (Lyman 1992) have also been used. A number of researchers found that seasonal changes in climate influence demand. Summer demand was found to be more elastic than winter demand (Lyman 1992, Dandy et al. 1997, Griffin and Chang 1990). Also, studies have found that outdoor water use is more elastic than indoor use.

Renwick and Green (1998) showed that non-price policies including campaigns, restrictions, and rationing policies have influence in decreasing demand. Nieswiadomy (1992) cites experience from a campaign in Tucson (USA) that was successful in decreasing demand only for a few years. He explains that the eventual return to initial consumption levels was caused by the fact that actual water prices did not rise. Furthermore, Nieswiadomy suggests that education programs will probably have more effect in water poor regions, because of the general awareness of water scarcity.

Abu Qdais and Al Nassay (2001) studied the impact of a change in pricing policy for Abu Dhabi City. Before the change, the water consumption was 636 L/capita/day. However, after changing the price policy from a fixed charge to a constant price per unit volume consumed ($0.6/$m^3$), the demand decreased. 73% of households studied decreased their consumption by an average of 29%. The price elasticity was found to be about -0.1.

A few authors used the Stone-Geary form to predict water demand and price elasticity (Matinez-Espineira and Nauges 2004, Gaudin et al. 2001, Al-Qunaibet et al.1985). The same function has been used in the past for modeling demand of food products, durable goods, transportation, and energy. Gaudin et al. (2001) proposed this function because it allows elasticity to decrease as the price increases and it uses only two parameters (γ and β) for each product. γ is defined as a threshold below which water consumption is not affected by prices, while β is the preference variable. Gaudin et al. (2001) specify the logic of this function in the following way: "The consumer is faced with a given level of income and set of prices. The consumer first purchases a minimum acceptable level of each good (the γ_i's). The leftover income, also called "supernumerary income," is then allocated in fixed proportions to each good according to their respective preference parameter (the β_i's)". Gaudin et al. (2001) presents the following demand function for water:

$$Q_w = \gamma_w + \beta \cdot \frac{I^* - P_w \cdot \gamma_w - \gamma_z}{P_w} \qquad (1)$$

where the subscripts *w* and *z* indicate parameters pertaining to water and to other goods respectively, while *I** and *P* represent income and price.

Price elasticities from different studies found in the literature are presented in Table 1. As seen, price elasticities vary within a wide range. This is due to the differences in socio-economic characteristics of the study areas, price schedules, price ranges, consumption levels, climate, income, awareness of water scarcity, and many other factors that can not all be accounted for.

Espey et al. (1997) and Dalhuisen et al. (2003) studied factors that affect price elasticities in demand models. Espey et al. evaluated 24 journal articles, while Dalhuisen et al. examined 64 studies. Both researchers found that studies that are based on regions with increasing block rate structures have larger price elasticities. Espey et al. (1997) found that models that account for evapotranspiration and rainfall predict less elastic demand, while including variables for temperature, population density and household size does not affect the elasticity. Dalhuisen et al. (2003) found that regions with higher income tend to have larger price elasticities. More recent references on the subject are: Carter and Milon(2005), Taylor, McKean, and Young (2004), Duke and Ehemann (2004), Cavanagh, Hanemann, and Stavins (2002), and Gaudin (2001).

3. Input Assumptions, Demand Models Used, and Adaptations Made

First, the assumptions made about the input to the demand models are presented. Then for each selected model, basic features are presented and the different adaptations made are explained.

3.1 Input Assumptions

As discussed in the previous section, a number of models assume that water demand is a function of household income and household size. Based on income and household size, consumers in Kuwait were divided into 40 groups.

Data regarding household income distribution in Kuwait was not available, so assumptions were made to estimate the distribution. It has been decided that the monthly household income be calculated using two approaches: (a) based on the distribution in the United States (U.S. Census Bureau), and (b) based on a Gaussian distribution . If the results of this approach do not differ substantially from the first approach, this may indicate that our results are not sensitive to the details of the underlying distribution. The second approach is presented only for one of the models (California model), and once it is shown that these two approaches do not produce substantially different results, the remaining analysis and results are based only on the U.S. income distribution.

In the case (a), a distribution for Kuwait was estimated by dividing the household income distribution in the US by the ratio of GDP per capita of the U.S. to that of Kuwait. Non-citizens were assumed to have half of the GDP per capita as Kuwaitis, and their income distribution was calculated in the same way. GDP per capita values for the US, Kuwaiti and Non-Kuwaiti households are presented in Table 2.

Information was gathered from the U.S. Census Bureau for U.S. household income distribution and the population was grouped into 5 income categories (Table 3). After dividing the U.S. income by the appropriate GDP ratio (1.7 for Kuwaitis and 3.4 for non-Kuwaitis), the household income groups in Table 4 were assumed and used as input for the simulations.

Table 5 shows the household size distribution in Kuwait as described by the Economic & Financial Quarterly of the National Bank of Kuwait (1999). This information was used to incorporate the distribution of household size into the demand models as described below.

The number of households in every category was transformed into the percentage of the total number of households (Table 6). The non-private non-Kuwaiti households listed in Table 5 were not considered as a separate group in this study. Instead, it was assumed that this group has the same distribution as private non-Kuwaiti households.

Every income group was assumed to have a household size distribution computed from Table 6 for the corresponding nationality. Therefore, every income group (five Kuwaiti and five non-Kuwaiti) was divided into four groups according to household size. This resulted in a total of 40 consumption groups that were used in the simulations.

In the approach (b), the same 40 consumer groups have been defined, but a different income distribution (Gaussian) has been applied (as explained above: the area under the applied distribution curves has not been changed). As discussed later, the results for approaches (a) and (b) differ by less than 1.5% (for the California model), which justifies our decision, in the rest of the analysis, to use only the approach (a). The study of Abu Rizaiza (1991) concludes that the elasticity results for USA and Saudi Arabia are relatively close to each other (in this study we analyze a neighboring country – Kuwait, and we treat a related problem – water reduction via price increase).

Pricing schemes that include a free allowance may be regarded as inefficient because different customers face different prices even though they are being served using the same economic mechanisms. One approach for handling these equity concerns is the establishment of relatively high prices per connection. However a few years ago, some countries in the region (Abu Dhabi) have moved from a charging 'per connection' system to a charging 'per m3 system', which resulted in non-trivial reduction of water consumption. This issue has been discussed in the economic literature (e.g., Griffin, J. Amer. Water Res. Assoc, Oct. 2001). An important aspect of this paper is the attempt to bridge the gap between economic and engineering perspectives on water planning. This study proposes an approach which reduces the water consumption through a pricing scheme, in the specific case of Kuwait. We do not advance any wider-scope theoretical argument.

An issue of relevance here is the correlation between household size and income. In reality, this correlation is sometimes positive and sometimes negative. With that in mind, we adopt an unbiased approach which assumes a zero correlation.

3.2 Models Used

Models from five different continents were used in these simulations. We believe that incorporation of a relatively large number of models in this study brings important advantages since it presents the variety of possible approaches (results of this study can be viewed in comparison with the results of other similar studies). The comparison of the results from models presented below represents a form of a sensitivity analysis. If five different models developed for conditions in five different continents give similar results, this would offer more credibility to the results of the Kuwait study.

An important contribution to the analysis of block-rate pricing mechanisms is the 'discrete-continuous' model developed by Hewitt and Hanemann (1995). They show that, in order to estimate a demand function under block-rate pricing, it is necessary first to estimate the block that an individual/household belongs to, and then to estimate its water use, in that block (not doing so would lead to biased estimates of the price elasticity of demand). However, the model is fairly complex and requires the existence of some input data types not available for the region of interest for this study. Consequently, the authors of this study have opted for simpler models that require readily available data.

The Saudi Arabia Model

<u>Specification</u>

Abu Rizaiza (1991) studied water consumption in four major cities in Saudi Arabia: Jeddah, Makkah, Madinah, and Taif. The study was based on data collected from a socio-economic survey conducted in 1985, water and sewage department circulars from Saudi Arabia, and from other publications. Different models were developed for residents who are supplied from the public water network, and from tankers. The average demand for water was 350 L/capita/day. The price schedule for the public water network was an increasing block tariff, with an average price of $0.09/m^3$. The model parameters were estimated using the ordinary least square framework.

The water demand equation uses a logarithmic functional form and calculates annual water demand per household as a function of a city-dependent constant (α_0), income, average price, family size, temperature and garden possession according to the following form:

$$Log(Q) = \alpha_0 + \alpha_1 \cdot Log(INC) + \alpha_2 \cdot Log(PRIC) + \alpha_3 \cdot Log(FSIZE) + \alpha_4 \cdot Log(TEMP) + \alpha_5 \cdot GRDN \quad (2)$$

Where *Q* is annual household demand, *INC* is household income, *PRIC* is average price, *FSIZE* is family size, and *TEMP* is temperature. The variable *GRDN* is equal to 1 if the family owns a garden and zero otherwise. The coefficients used in this model can be found in Abu Rizaiza (1991) in Table 3 in the column for houses supplied by the Public Network System

Adaptation

Using the water demand equation (2) and the original coefficients demand was computed for each of the consumption groups in Kuwait using a range of prices. Average temperature was assumed to be 31ºC, and the garden parameter was not used, since data about garden ownership was not available.

In order to simulate the effect of a free monthly water allowance in the pricing schedule, the first 4.5 m^3/capita/month (or 150 L/capita/day) was computed with a price of $0.1/$m^3$ (since the model has a logarithmic from, a zero price could not be calculated), which was assumed to be a good approximation of free water. All consumption beyond 4.5 m^3/capita/month (or 150 L/capita/day) was priced at the constant price rate.

Next, the model coefficients were adjusted to Kuwait. Since there has not been a price increase in the recent years, the only point that is known on the demand-price graph is a value around 450 L/capita/day (13.5 m3/capita/month) for a situation when water is almost free. The constant (city dependent variable) in the model was adjusted to obtain a demand around 450 L/capita/day for a constant price of \$0.1/m^3. Based on this procedure, the appropriate value for the constant (α_0) is zero.

The California Model

Specification

This model, developed by Renwick and Green (2000), was based on data in California for about 7.1 million people from eight water agencies during 1986-96. The model focuses on the influence that price policies and non-price policies have on decreasing water demand. Three types of equations are used in this study: a water demand equation, price equations, and climate equations. Household water demand was derived as a function of price variables, household income, lot size, precipitation, temperature and non-price policies, and has a logarithmic functional form. The water demand equation is:

$$\ln W_{it} = \beta_0 + \beta_1 \cdot \ln(MP_{it}) + \beta_2 \cdot \ln(D_{it}) + \beta_3 \cdot \ln(INC_{it}) + \sum_{i=4}^{9} \beta_i \cdot (NPDSM) + \beta_{10} \cdot LIRR_{it} + \beta_{11} \cdot HIRR3_{it}$$
$$+ \beta_{12} \cdot \ln(TEMP) + \beta_{13} \cdot \ln(PREC_{it}) + \beta_{14} \cdot LOT + \beta_{15,j} \cdot \sin\left(\frac{\pi ijt}{6}\right) + \beta_{16,j} \cos\left(\frac{\pi ikt}{6}\right) + e_{i,j} \quad (3)$$

Where:

i=1,…,8 agencies (cities)

t = 1,…,96 months (time)

j=1…5

k=1…6 (bi-monthly harmonic)

W_{it} = Household Water Demand per month

MP_{it} = Marginal price

D_{it} =Difference variable (the difference between what would have been paid if all units were purchased at MP and the amount paid under the block pricing schedule)

INC_{it} = Income in $1000

HH_{it} = Number of household members

NP DSM = 6 non-price Demand Side Management (DSM) policies

$LIRR_{it}$ = 1 if expected low irrigation/outdoor use, zero otherwise

$HIRR_{it}$ =1 if expected high irrigation/outdoor use, zero otherwise

$PREC_{it}$ = cumulative monthly precipitation

$e_{i,j}$ = error term

Values of some of the coefficients used in the water demand equation of the California Model are presented in the column named “California” in Table 7. The full list can be found in Renwick and Green (2000). Price and Climate equations are not presented here, since they are not related to this study.

In this study a range of marginal prices between $0.16 – $1.6 per m^3 was analyzed. The model incorporates price policies, alternative non-pricing campaigns, and seasonal and climatic variability on demand. The coefficients in equation (3) were estimated in a generalized least-squares framework. A price elasticity range of 16-20% was found in the study. The authors find that non-price policies do influence demand. Also, the authors conclude that “price policy may achieve a larger reduction in aggregate demand in lower income communities than in higher income communities” (Renwick and Green 1998).

Adaptation

Since the free allowance was specified per capita and this model predicts household consumption, a household size variable is needed. However, in the original model, household size is not directly incorporated in the demand equation, though it is part of the price equation.

One of the authors of the “California” model (Renwick) published a similar paper with Archibald (1998) that was also based on data from California during a similar period. The household size variable was used in the demand model of this paper. However, this model (Renwick and Archibald 1998) was not used for this study, since it has a linear form and coefficients were found to be harder to calibrate. Since a household variable was used for a similar study, the variable was added to the demand equation in the Renwick and Green (2000) model. A similar value of the coefficient used in the price equation was used for the demand equation for household size (β_4 =0.2). In the simulations, the household size element had a negligible contribution compared to the other elements in the equation, and did not have a significant influence on the price elasticities, but it was included in order to be consistent with the price proposal.

Using the water demand equation (3) and the coefficients in the California column of Table 7, demand was computed for each consumption group for a range of prices. Then the model coefficients were recalibrated for Kuwait. The income coefficient was increased by a factor of 2, since the GDP in the USA is close to twice the GDP per capita for Kuwaiti and Non-Kuwaiti households, though this assumption may not be adequate, since the function has a logarithmic form. The constant coefficient was then recalibrated to get a demand of around 450 L/capita/day (13.5 m3/head/month) for a price of $\$0.1/m^3$. Other coefficients remained the same. Table 7 shows the values of the recalibrated coefficients in the Kuwait column. In order to simulate the effect of a free monthly per capita water allowance in the pricing schedule, the first 4.5 m^3/capita/month (150 L/capita/day) was computed with a price of $\$0.1/m^3$, assumed to be close enough to zero. All consumption after that quantity was priced at the constant rate.

The Australia Model

<u>Specification</u>

This study by Dandy et al. (1997) differs from other studies reviewed because the influence of a free allowance in the pricing regime was analyzed. It was based on data from the metropolitan area of Adelaide, Australia. The results of this study showed that “consumption above the allowance is more sensitive to income (or property value), climate variables (summer moisture deficit and winter evaporation), and pool ownership than consumption below the allowance but responds to the need of water as determined by plot size, household size, and number of rooms no differently from consumption below the allowance” (Dandy et al. 1997). While this study presents both static and dynamic models, only the static variation is considered here. The model is linear and is applied on an annual time scale. The static demand model was used for this study.

The demand model is specified differently for consumers who consume more than the allowance and those who consume within the allowance. For consumers within the allowance, water demand is a function of lagged consumption (Q_{-1}), property value, variables such as household size, climate, etc. (Z variables) and D_y, a dummy variable for the year 1992. The demand equation in this case is:

D = 0 for Q < A;   D = 1 for Q > A

$$Q = \alpha_0 + \alpha_1 \cdot Q_{-1} + \beta_1 \cdot I + \mathrm{B}\mathrm{Z} + \theta \cdot D_y + \delta_0 D + \delta_1 \cdot D \cdot Q_{-1} + \gamma_1 \cdot D \cdot I + \Gamma \cdot D \cdot \mathrm{Z} + \Phi \cdot D \cdot \mathrm{P} + u \quad (4)$$

Where:

Q = quantity of water consumed

A = annual allowance

I = property value

P = a vector of price variables (marginal price, difference variable)

Z = a vector of other variables (household size, number of rooms, pool, etc.)

D = variable showing if demand is above or under the allowance

Q_{-1}= quantity of water consumed in the previous year

D_y=1 for year =1992 and D_y=0, otherwise

u =error term

The original coefficients in this model can be found in Dandy et al. (1997) in Table 1 (Annual Consumption Models)

<u>Adaptation</u>

The original coefficients were used for the simulations with the exception of D_y and property value. D_y was not used since it is specific to Australia and the lagged consumption was not included since the static annual model was used. Property value was not used in the simulations, because of the lack of data.

The original model used property value instead of income, since not enough data was available to the researchers regarding annual income in Adelaide. However, in the simulations for Kuwait income was used instead of the property value. The income coefficient was computed so that the model would simulate an average demand of 450 L/capita/day (13.5 m3/capita/month) for a price of zero. The property value coefficient used in the Australian model was divided by 133 to obtain the Kuwaiti demand for a zero price of water. This indicates that for an average family, the value of the property that they own is equal to the income that they earn in 133 months (11.1 years).

So, in the demand equation for consumption below the allowance, income was multiplied by a value of β_1=0.00535. For consumption above the allowance income was multiplied by ($\beta_1+\gamma_1$) = 0.011. Also, Australian dollars were used in the simulation, and then converted to US dollars using an exchange rate of 1USD = 1.37 Australian dollars (April 2006)

The Australia model is based on an annual allowance of 136 m^3 per household. Since the average household in Adelaide has 2.6 members (Australian Bureau of Statistics, 1991), the allowance is 143 L/capita/day on average. This is close to the allowance that we will propose for Kuwait. However, we assume an average household size of five members for Kuwait. Because the quantity of the allowance in this study is defined per capita, this difference in household size requires the model to be adjusted for Kuwait.

In this model, the change in water demand due to price influences is a function of the marginal price (MP) and the difference variable (DV). The part of the demand equation (Eq. 4) that computes the influence of the price is ΦP. The vectors can be expanded to an equation with the form $\beta_2 \cdot MP + \beta_3 \cdot DV$. In a pricing schedule that consists of a free allowance followed by a constant price, the DV is equal to the quantity of the household allowance multiplied by the marginal price of water, with a minus sign. If the household allowance (A_H) is specified to be per household member with an allowance of 143 L/capita/day (52.2 m^3/capita/year), then:

$$Q_p = \beta_2 \cdot MP + \beta_3 \cdot DV$$

$$Q_p = \beta_2 \cdot MP + \beta_3 \cdot (-A_H \cdot MP)$$

$$Q_p = -404.4 \cdot MP + 1.37 \cdot 52.2 \cdot HH \cdot MP \qquad (5)$$

Where Q_p is the part of the demand equation that determines the influence of price, *HH* is household size, β_2 and β_3 are the coefficients for the marginal price and difference variable from Table 1 (Annual Consumption Models) in Dandy et al. (1997)

For a household size of 2.6 members (Adelaide average), the right hand side of equation 5 is equal to $-218.08 \cdot MP$. If the same logic is applied for a household size of 5, equation 5 becomes equal to $-48.9 \cdot MP$, resulting in less price elasticity simply due to the increase in household size. However, these two factors should not be correlated. For a household with 12 members, the price influence would be equal to $453.70 \cdot MP$, implying that an increase in price would increase the consumption for large households.

In order to get the same influence of the marginal price in the demand equation ($-218.08 \cdot MP$), the next relationship was used:

$$\beta_3 \cdot DV = -1.37 \cdot 52.2 \cdot 2.6 \cdot MP = \beta_3^{'} \cdot 52.2 \cdot 5 \cdot MP \quad (6)$$

where 2.6 is the average household size in Adelaide and 5 is average household size in Kuwait used in the simulations. Then for the adjusted DV coefficient (β_3') we have:

$$\beta_3^{'} = \beta_3 \cdot \frac{2.6}{5} = -1.37 \cdot 0.52 = -0.71. \quad (7)$$

For this model, a fixed allowance is required, so a value of 275 m^3/household/year (or 0.75 m^3/household/day) was used. This amount was chosen based on the average household size of 5 members and a per capita allowance of 150L/day.

The Tunis Model

Specification

This model, developed by Ayadi et al. (2003), was based on water demand data collected in Tunis from 1980 to 1996. The authors initially divided the consumers into five brackets based on water demand. However, based on similarity in their reactions to price increases, the lowest two brackets were combined into one (lower) block, and the highest two brackets were combined into another (higher) consumption block. The model does not consider the middle bracket.

Different coefficients were used for the high and low demand blocks, specifying that the price elasticity of the upper block (estimated to be around -0.4) is larger than the price elasticity of the lower block (-0.1). The water demand equation (8) is a function of income, average price, network size, rainfall and quarterly dummies. The model also computes household shifting from one bracket to the other (Eq. 9).

Demand equation:

$$Log(C) = \alpha_0 + \alpha_1 \cdot Log(R) + \alpha_2 \cdot Log(P) + \alpha_3 \cdot Log(N) + \alpha_4 \cdot Log(RL) + \sum_{s=1,2,4} \alpha_{5s} \cdot QD_{st} + \varepsilon \quad (8)$$

Portion of households in each bracket:

$$Log(NB/N) = \gamma_0 + \gamma_1 \cdot Log(P) + \gamma_2 \cdot Log(N) + \gamma_3 \cdot Log(RL) + \sum_{s=1,2,4} \gamma_{5s} \cdot QD_{st} + \varepsilon \quad (9)$$

Where:

C= average consumption of water per household [m^3/month]

R = average monthly income of households ($1000)

P = average water bill paid by household ($/month)

N = network size (incorporated to capture the effect of network expansion)

RL= indicator of rainfall

QD = quarterly dummy

NB = number of consumers in each bracket

ε = error term

The original coefficients used for adapting this model to Kuwait can be found in Ayadi et al. (2003) in Table 1a (Water Demand Equation) and Table 1b (Consumers proportion equation) in the column for the average price variable used, GLS2 estimation and for the Greater Tunis area.

<u>Adaptation</u>

The rainfall, quarterly dummies and network expansion variables were not used in the simulations. The first and second Kuwaiti income groups (Table 4) compose the lower bracket and the fourth and fifth Kuwaiti income groups (Table 4) create the upper bracket. This led to a smaller percentage of the population in the lower bracket and a larger percentage in the higher bracket than in the original model. This consequently increases the price elasticity because the model is specified to have a higher elasticity for the upper block. To calibrate the model for Kuwait, the α_0 coefficients were adjusted to get a demand around 450L/capita/day (13.5 m3/capita/month) for a price near zero. The γ_0 coefficients were changed in order to match the group divisions specified above. Table 8 presents the coefficients that were changed in order to adopt the Tunis model.

The Spain Model

Specification

Of the three models in the literature that use the Stone-Geary functional form, the model developed in Spain was selected. This model was chosen because Spain has a GDP similar to that of Kuwait, and because the MP and difference variables were used in the model, which should be appropriate for the price schedule proposed. The model was estimated using the Feasible Generalized Least Squares framework (FGLS).

The authors give the next equation:

$$Q_w = (1-\beta)\cdot\gamma + \beta\cdot\frac{I_t}{P_t} - 0.033\cdot BAN_t - 0.081\cdot POP_t + \varepsilon_t \qquad (10)$$

Where:

Q_w = average per capita consumption

P_t = the marginal price of water

I_t = virtual income, the difference between the average salaries and the difference variable

BAN_t = binary variable, indicating influence of out-door-use bans

POP_t = daily hours of supply restrictions

γ = 4.7 and represents the minimum consumption level

β = 0.0008 and represents “the marginal budget share allocated to the good considered”

ε_t = error term

<u>Adaptation</u>

The BAN and restriction variables were not used for the Kuwait simulations. The same values of the coefficients γ and β from the original model were used in simulating demand for Kuwait. Aggregate data was used in the simulation, rather than the group-specific data used with the other models. The GDP per capita for Kuwait ($21,300) was used in order to estimate the average monthly income.

Model constrains and assumptions

The situation in Kuwait, where water bills are issued but not collected efficiently differs from the situations where these demand models were developed. The difference between Kuwait’s type of system and the typical free water situation has not been studied, so it is unclear how this difference will affect the performance of demand models. Also, in the studies reviewed here, water prices increased from an initial price significantly larger than a zero. In addition, simulating a price increase of $2/m^3 (e.g. from 0 to $2/m^3) is a larger price range than what most of the models were designed to simulate.

Furthermore, due to a lack of data, not all of the variables that were specified in the original models were used to simulate water demand in Kuwait. Weather, density of housing, seasonal influences and other variables were assumed constant and incorporated into the constant (intercept). This alteration of the models might have an influence on the simulated demand.

In models that use the marginal price, numerical errors occur when a consumption group shifts from one water price in the block tariff to another due to a price increase. When the price of water gradually increases, the water demand of a group gradually decreases. When the demand approaches the border of two tariff blocks, (e.g. the upper limit of the free allowance) it does not fit in either of the blocks. In other words, when demand is computed for the lower block (with the MP for the lower block, and therefore a less negative price variable), it exceeds the lower block demand, going into the higher price block. But when computed for the higher block (with a higher MP and a more negative price variable), the calculated demand is below the limit for the higher block. This numerical problem was solved by specifying the demand for these consumption groups to be equal to the border value between the two blocks.

4. Results

4.1 Simulation of a Constant Price Schedule

Results regarding the influence of a constant price schedule on per capita demand are presented in Figure 2, and show that pricing influences the demand. All models predict different price elasticities, since they are based on data from different studies. The models that have a logarithmic or Stone-Geary functional form show that after a price of around $0.8/m^3, further price increase does not significantly influence the quantity demanded.

The monthly government subsidy for a constant price schedule is shown in Figure 3. It was simulated assuming a production cost of $3/m^3. The subsidy was computed for a population of 2.2 million, to be consistent with Kuwait's current population. All models show that water pricing would significantly decrease the monthly subsidy by around $60 million for a price of $1/m^3.

4.2 Simulation of a constant price following a free allowance

As specified earlier, a simple pricing schedule is proposed: a constant price schedule with an initial free allowance (Figure 1). It is specified by two parameters: the quantity of the allowance and the constant price per volume of additional water consumed. To specify the quantity of the allowance, water consumption in Kuwait was compared to other countries. Most European countries use around 150 L/capita/day. This amount satisfies the needs of an average person. Since the goal of the pricing schedule is to eliminate the waste of water, all water used beyond the allowance needs to be priced.

In this proposed schedule, the first 4.5 m^3/capita/month (or 150 L/capita/day) would be free of charge, while all additional consumption would be charged using prepaid cards. Hence, at the beginning of every month, the amount of the allowance could be added to the card at no cost. Each home would be equipped with a water meter capable of deducting credits from the prepaid card and limiting water flow to the designated amount.

Figure 4 indicates that this kind of pricing schedule will decrease demand. Similar to the previous simulation, the models with logarithmic and the Stone-Geary forms predict that after a price of 0.8 $/m3 the demand does not show much reduction with further increases in price (Figure 4), indicating that there is a quantity of water that shows minimal response to prices. The linear Australian model suggests that a price of $\$1/m^3$ would decrease the demand to a consumption level around 200 L/capita/day (Figure 4). Overall, the models show that an allowance of 150L/capita/day (or 4.5 m3/capita/month) followed by a constant price of $\$1/m^3$ would decrease the demand by 17% to 41%, depending on the demand model used, with an arithmetic average of about 32%. The circle in Figure 4 represents the point on the demand-price graph for which the coefficients were recalibrated in the models.

The amount of government subsidy (Figure 5) was computed in the same manner as in the simulation without an allowance. All models predict a decrease in subsidy around 40 million dollars per month, for a price of $\$1/m^3$.

4.3 Elasticities

Models used in these simulations are based on studies from arid regions in five continents: North America (California), Europe (Spain), Asia (Saudi Arabia), Africa (Tunis) and Australia. Since the models are based on data sets from different regions of the world, they predict different price elasticities. Table 9 presents the price elasticities in the original studies and those calculated based on the simulations for Kuwait. As shown in Table 9, elasticities in the simulations differ from original values for some of the models. This divergence might be due in part to the fact that not all the variables in the original models were used in the models for Kuwait. The allowance also has a significant impact on the elasticities.

The California model: For the simulations without an allowance, the elasticity is in the range of the original model. However, in the simulations with the allowance, the elasticity is smaller. This is partly due to the fact that when an allowance is simulated, a fraction of consumers are using less water than the amount of the allowance, and since they are not paying for water, they are not influenced by price increases.

The Australia model: The original model was based on an allowance, so it specifies that a portion of the households consume within the allowance, and are not influenced by prices. Thus, when simulations without an allowance are performed, all the consumers are influenced by price increases, resulting in a larger elasticity. Simulations with an allowance predicted smaller price elasticities than the original model. This may be because the allowance in the simulations for Kuwait was larger than in the original model. Also, the Australia model has a linear form, so elasticities vary with price.

For the California and Australia models, income groups that numerically did not fit either above or below the allowance were fixed to be on the border. To check if this would influence the elasticities, a simulation was conducted using only groups that do not have this problem at any price range (33 groups for the California model and 27 groups for the Australia model). The results showed almost identical results to those computed for all forty groups. The models showed that the way the shifting between blocks was accounted for has an insignificant influence on elasticity. However, the demand function was totally linear when only groups without errors were used, while when all groups were used there was some non-linearity in the Australia model (Figure 4).

The Spain model: Since this model has a Stone-Geary functional form, elasticities change with prices. The elasticity decreases as the price increases.

The Tunis model: the assumed household income distribution (Table 4) led to a smaller percentage of the total population in the lower consumer block and a larger percentage in the higher block than in the original model. This increases the price elasticity, because the model is specified to have a higher elasticity for the upper block. The income in Kuwait is higher than in Tunis.

Computing marginal price elasticities for models that use the average price as a variable might not present the results in the best way, but this was done in order to compare all the models in a consistent manner.

4.4 Influence of the allowance and price on demand reduction

The influence of the allowance on demand reduction for various prices is presented in Figure 6 for the Australia model and in Figure 7 for the Saudi Arabia model. The initial demand was computed from simulations using the Australian and Saudi Arabian models with an allowance followed by a constant price of \$0.25/m^3, then the price was increased and the corresponding demand reduction was calculated. This procedure was then repeated for different allowances. Both models indicate that the price has a larger influence on demand than the size of the allowance. For different values of the allowance, the initial demand differs slightly, but these initial values have an insignificant influence on the demand reduction percentage. Table 10 shows demand reduction simulated for all models at a marginal price of \$1/m^3 for an allowance of 150 L/capita/day (or 4/5 m3/capita/month).

4.5 Changes in the distribution of consumption

The distribution of water demand, computed using the Australia model for simulations of a free allowance followed by a constant price, is presented in Figures 8-10 for different prices. The figures show that at a price of zero, there will be no households with consumption less than 150 L/capita/day. However, for a price of $2/m^3, around 50% of the population will consume less than the 150L/capita/day allowance.

In Figure 11 we present the subsidy in terms of the percentage of total cost. This figure can be used as a justification for the utilization of the proposed mechanism – it shows clearly the relative contribution of consumers and the government to the overall cost.

The models used are based on the analysis of data from very different time periods. Different time periods may imply the availability of different water-using technology and also different metering technology in general. However, we believe that the impact of this issue is marginal, since there is evidence (based on a meta-analysis study) that elasticities would change only little with time (Dalhuisen et al., 2003).

4.6 Discussion of the household income distribution choice

In principle, one can question the selection of the household income distribution (HID) for Kuwait used in this paper. In the absence of the official data for HID of Kuwait, this study uses a scaled HID for USA. A legitimate question is how large is the error created in such a way. The initial assumption was that the error is negligible. Using the approach defined next, it has been shown that the error is (in the extreme case) less than 1,5%. For clarity purposes, the adopted approach is presented here in detail:

1. The mean value (m) for the HID of USA is found, after it was first scaled by the factors of 1.7 and 3.4, respectively (as used elsewhere in this study).
2. The total area (A) under the HID curve for USA is found.
3. The variance (σ^2) of a Gaussian distribution curve is found, which is characterized with the same mean (m) as in the point (1) above, and the same area (A) as in the point (2) above.
4. The Gaussian curve with the mean (m) from the point (1) above, and the variance (σ^2) from the point (3) above is used to serve as an approximation of the unknown HID for Kuwait.
5. Two extreme scenarios are recomputed using the HID from the point (4) above.
6. The worst-case differences between the initial computation (using the scaled HID for USA) and the later computation (using the Gaussian type HID) is measured.
7. The worst-case difference from the point (6) above is determined to be less than 1.5%, which suggests that the calculation is relatively insensitive to the shape of the HID, and consequently that the initial calculation (based on the HID for USA) is valid.

A new curve, labeled as "California – Gauss Distribution", derived using the above procedure, is added to Figure 4 (dashed, so one can easily notice the fact that the worst-case difference is extremely small (or, 1. 5 %, as indicated above).

5. Discussion and Conclusion

These results show that pricing water in Kuwait would decrease the demand to an acceptable level. The models computed that a price of $1/m^3 after a 150 L/capita/day (or 4.5

m3/capita/month) allowance would decrease the demand by 20 to 40 percent, with an arithmetic average of around 32 percent. For simulations without an allowance, the arithmetic average of the demand reduction for the five models was found to be around 45 percent for a constant price of $1/m^3.

As expected, marginal price elasticities were shown to be slightly larger for a schedule without an allowance. However, paying for water in Kuwait is not the normal practice, so water bills could be perceived as a burden that might not be widely accepted. From a political and socio-economic point of view, a free allowance would certainly be a more acceptable solution to address Kuwait's immense water demand problem. It would be up to the Kuwaiti government to choose appropriate values for the price and allowance.

Since the main objective of introducing a pricing schedule is to eliminate the waste of water, this type of pricing with a free allowance would address this problem. Also, the results presented would be similar for other countries in the Gulf region, where water is generally under-priced.

The decision of which demand models to use should not influence the projected demand reduction. Since data of demand characteristics is not available for Kuwait, divergence might occur, but these five models generally have similar results, so the range of predictions obtained for the influence of the proposed pricing schedule should be sufficiently accurate. Further research should to be done in order to improve water demand modeling for Kuwait. Studies should be conducted to determine a distribution of how water is used. In addition, water consumption should be metered. This would allow further studies to analyze household consumption and how it relates to characteristics such as income, household size, pool

7. References:

Abu Qdais, H.A. and Al Nassay, H.I. (2001), Effect of Pricing Policy on Water Conservation: A Case Study, *Water policy 3(3): 207-214.*

Abu Rizaiza, O.S. (1991), A Case of the Major Cities of the Western Region of Saudi Arabia, *Land Economics 27(5): 667-671.*

Al-Qunabeit, M.H. and Johnston, R.S. (1985), Municipal Demand for Water in Kuwait, Methodological Issues and Empirical Results, *Water Resources Research 2 (4):433-438.*

Arbues, F., Garcia-Valinas, M. A., and Martinez-Espineira, R. (2003), Estimation of residential water demand: a state-of-the-art- review, *Journal of Socio-Economics 32(1): 81-102.*

The Australian Bureau of Statistics (2001) Census; Adelaide Social Atlas.

Ayadi, X., Krishnakura, X., and Matoussi, X. (2003), A Panel Data Analysis of Water Demand in Presence of Nonlinear Progressive Tariffs.

Billings, R.B. and Agthe, D.E. (1980), Price Elasticities for Water: A Case of Increasing Block Tariffs, *Land Economics 56 (1): 73-84.*

Billings, R.B. (1982), Specification of Price Rate Variables in Demand Models, *Land Economics 58(3): 386-393* .

Carter, D.W. and Milon J. W. (2005), Price Knowledge in Household Demand for Utility Services, *Land Economics, 81 (2) pp. 265-283.*

Cavanagh, S.M., Hanemann, M.W., and R.N. Stavins (2002), Muffled Price Signals: Household Water Demand under Increasing-Block Prices, *FEEM working paper No. 40.02, Fondazione Eni Enrico Mattei, Florence, Italy.*

Chicoine, D.J. and Ramamurthy, G. (1986), Evidence on the Specification of Price in the Study of Domestic Water Demand, *Land Economics 62 (1) : 26 - 32*

Dandy, G., Nguyen, T., and Davies, C. (1997), Estimating Residential Water Demand in the Presence of Free Allowances, *Land Economics 73(1): 127-139.*

Dalhuisen, J. M., Florax, R., de Groot, H., and Nijkamp, P. (2003), Price and Income Elasticities of Residential Water Demand: A Meta-Analysis, *Land Economics 79(2):292-308.*

Darwish, M.A. and Al-Najem, N. (2005), The Water Problem in Kuwait, *Desalination 177:167-177.*

Darwish, M.A., Al Asfour, F., and Al-Najem, N. (2002), Energy consumption in equivalent work by different desalting methods: case study of Kuwait, *Desalination 152: 83-92.*

Duke, J. M. and Ehemann, R., (2004), An Application of Water Scarcity Pricing with Varying Threshold, Elasticity, and Deficit, *Journal of Soil and Water Conservation, 59 (2) pp. 59-65.*

Economic & Financial Quarterly i/1999 - Kuwait National Bank.

Espey, M., Espey, J., and Shaw, W.D. (1997), Price Elasticity of Residential Demand for Water: A Meta-Analysis, *Water Resources Research 33(6): 1369-1374.*

European Water Association Yearbook, 2005.

Fadelmawla and Al-Otaibi (2005), Analysis of the Water Resources Status in Kuwait, *Water Resources Management 19: 555-570.*

Foster, H.S., and Beattie, B.R. (1981), On the Specification of Price in Studies of Consumer Demand under Block price Schedules, *Land Economics 57(4): 624-629.*

Foster, H.S., and Beattie, B.R. (1979), Urban Residential Demand for Water in the United States, *Land Economics 55(1):43-58.*

Gaudin, S., Griffin, R., and Sickles, R. (2001), Demand Specification for Municipal Water Management: Evaluation of the Stone-Geary Form, *Land Economics 77(3): 399-422*

Gaudin, S. (2006). Effect of Price Information on Residential Water Demand. *Applied Economics 38(4), pp. 383-93.*

Griffin, R.C., and Chang, C. (1990), Pretest Analysis of Water Demand in Thirty Communities, *Water Resources Research 26 (10): 2251-2255.*

Hamoda, M.F. (2001), Desalination and Water Resource Management in Kuwait *Desalination 138: 385-393.*

Hansen, L.E. (1996), Water and Energy Price Impacts on Residential Water Demand in Copenhagen, *Land Economics 72(1), pp 66-79*

Hewitt, J.A., and Hanemann, W.M. (1995), A discrete/continuous choice approach to residential water demand under block rate pricing, Land Economics 71(2), pp. 173-192.

Hoglund L. (1999), Household Demand for Water in Sweden with Applications of a Potential Tax on Water Use, *Water Resources Research 35 (12): 3853-3863*

Lyman, R.A. (1992), Peak and Off-Peak Residential Water Demand, *Water Resources Research 28(9):2159-2167.*

Martinez-Espineira, R., and Nauges, C., (2004), Is All Domestic Water Consumption Sensitive to Price Control?, *Applied Economics 36, 1697-1703.*

Nauges, C., and Thomas, A. (2000), Privately Operated Water Utilities, Municipal Price Negotiation, and Estimation of Residential Water Demand: The Case of France.
Land Economics 76(1): 68-85.

Nieswiadomy, M.L. (1992), "Estimating Urban Residential Water Demand: Effects of Price Structure, Conservation, and Education." *Water Resources Research 28 (3) 609-615.*

Nieswiadomy, M.L., and Molina, D.J. (1991), A Note on Price Perception in Water demand Models, *Land Economics 67(3): 352-359.*

Nieswiadomy, M.L., and Molina, D.J. (1989), Comparing Residential Water Demand Estimates Under Decreasing and Increasing Block Rates Using Household Data,
Land economics 65(3): 280-289.

Nordin, J.A. (1976) A proposed modification on Taylor's demand-supply analysis: comment,
The Bell Journal of Economics, 7, 719-21

Renwick, M.E., and Archibald, S.O. (1998), Demand Side Management Policies for Residential Water Use: Who Bears the Conservation Burden?, *Land Economics 74(3):343-359.*

Renwick, M.E., and Green, R.D. (2000), Do Residential Water Demand Side Management Policies Measure Up? An Analysis of Eight California Water Agencies,
Journal of Environmental Economics and Management 40: 37-55.

Taylor, R. G., McKean, R. J., and Young, R. A. (2004),
Alternate Price Specifications for Estimating Residential Water
Demand with Fixed Fees, *Land Economics 80 (3) pp. 463-475*.

Figure 1: Price Proposal: A free allowance followed by a constant price

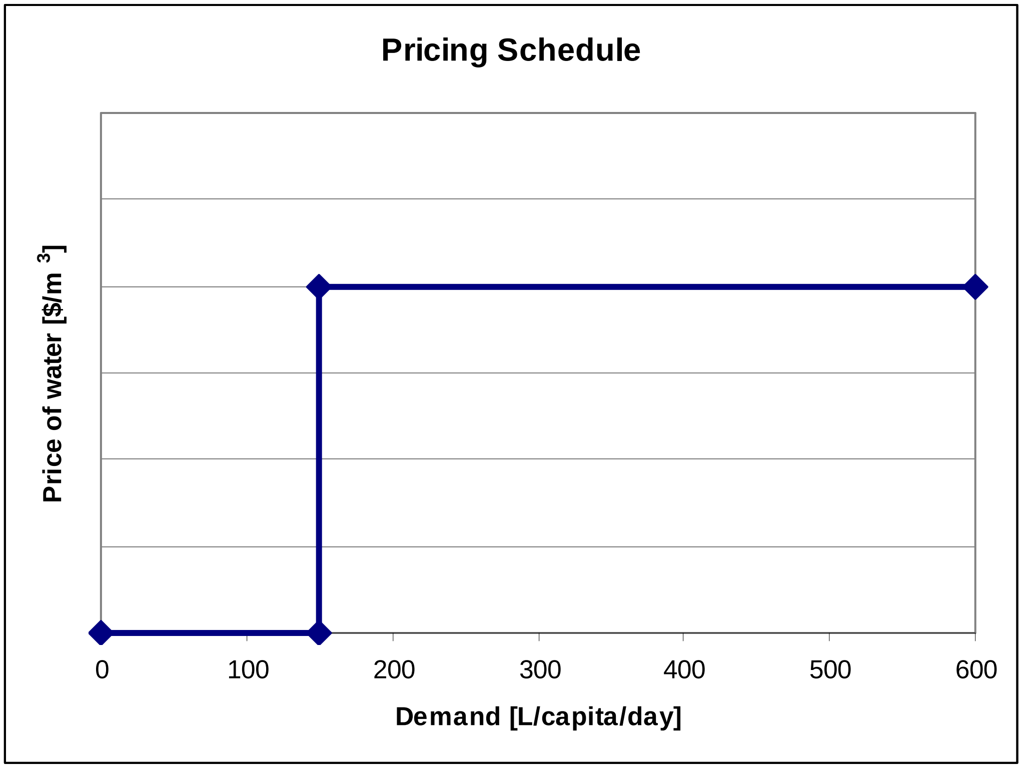

Figure 2: Decreases in demand for a constant price schedule without an allowance using the re-calibrated models

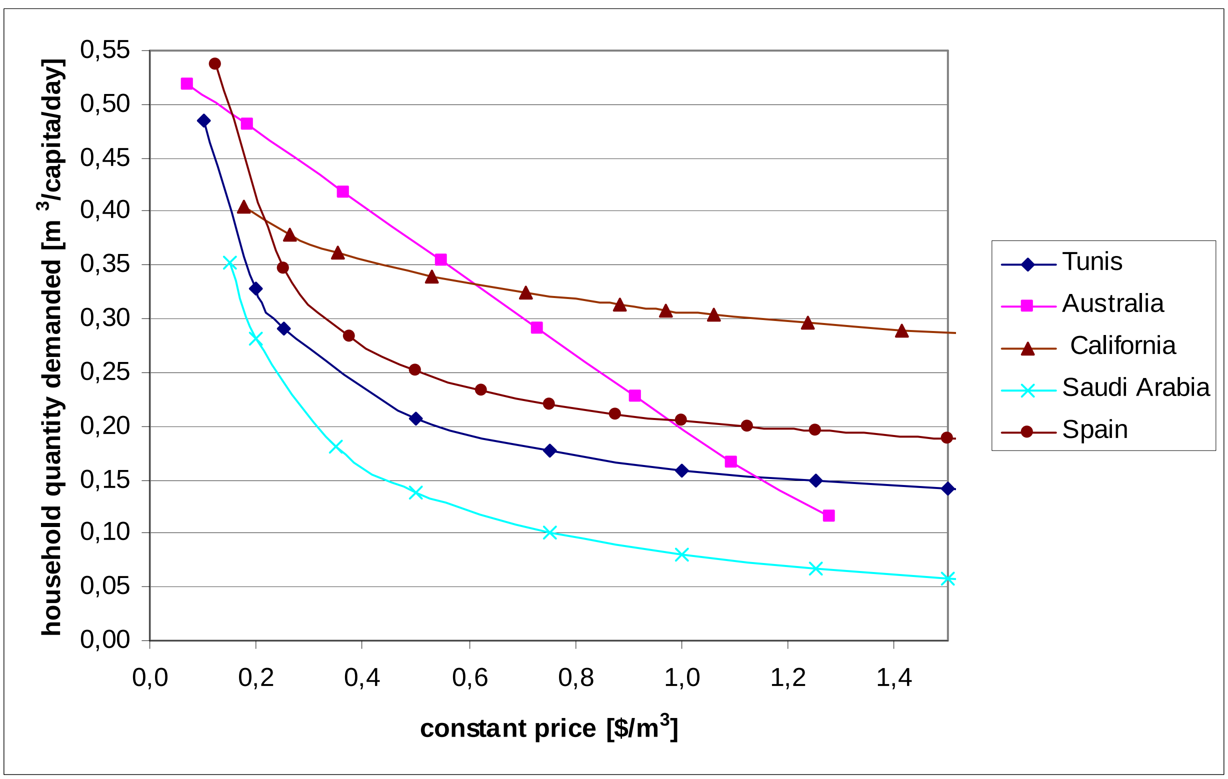

Figure 3: Monthly government subsidy in Kuwait for a constant price schedule without an allowance

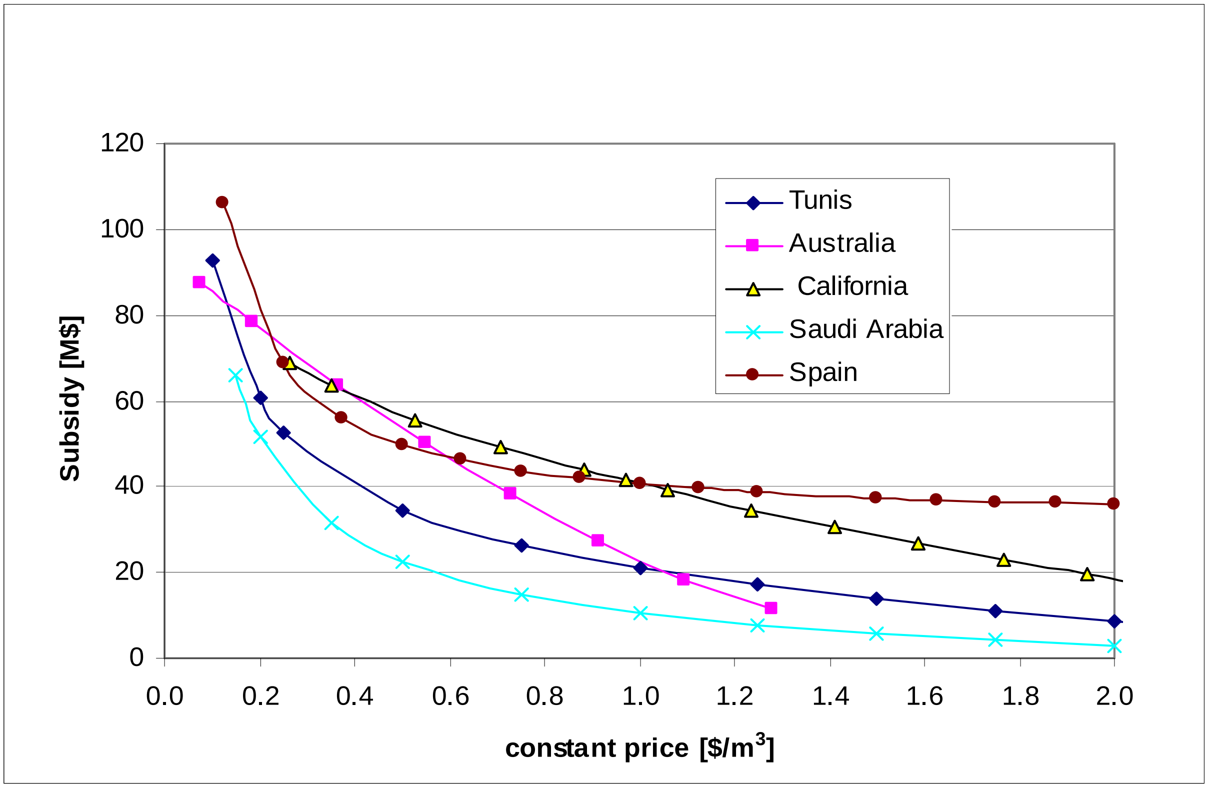

Figure 4: Predicted demand for a 150L/capita/day (or 4.5 m3/head/month) allowance followed by a constant price

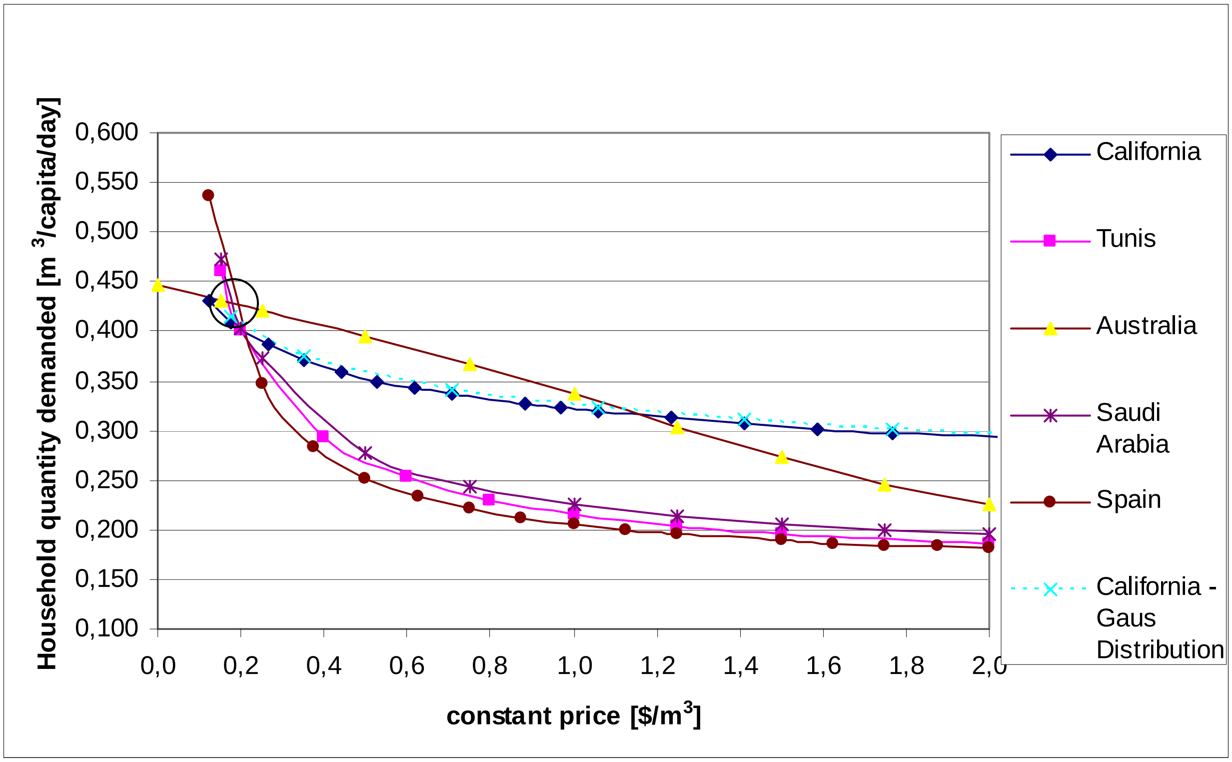

Figure 5: Government subsidy for a price schedule of 150L/capita/day (or 4.5 m3/capita/month) free allowance followed by a constant price

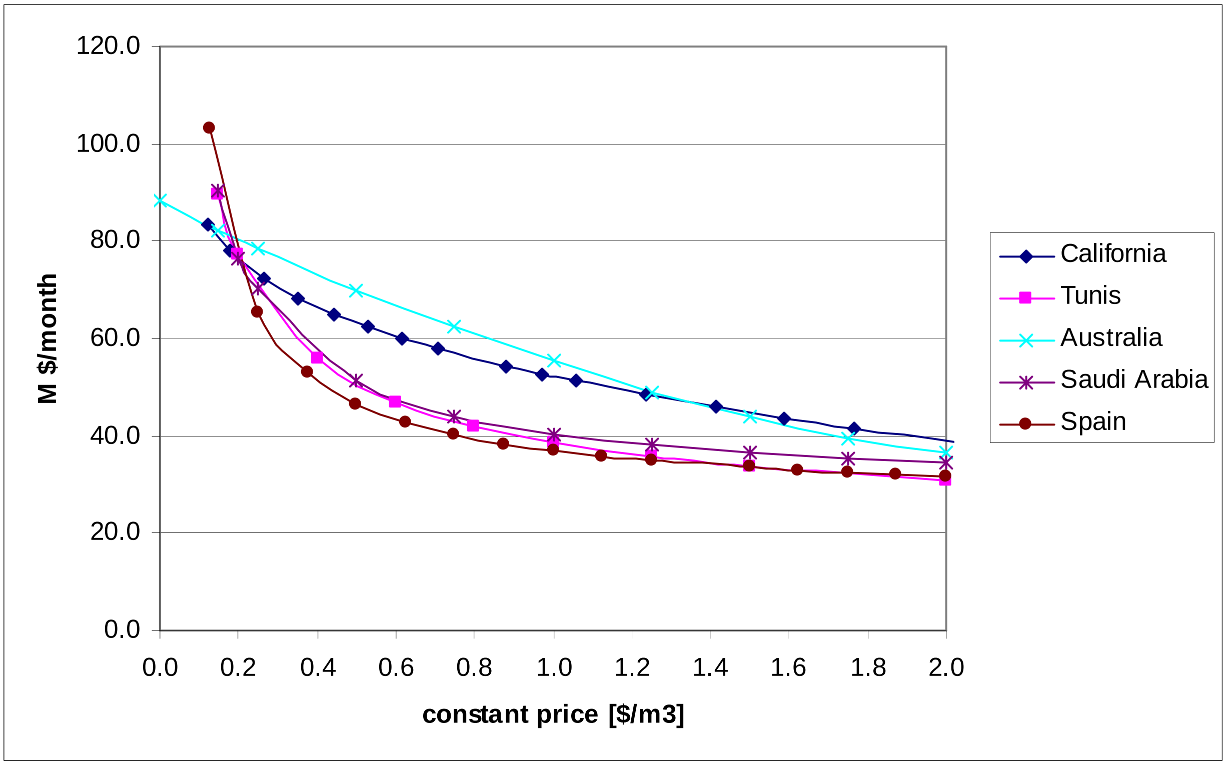

Figure 6: Influence of the allowance and price on demand reduction for the Australian model. Lines represent equal percentage reduction from an initial demand computed for a price of $0.25/m^3

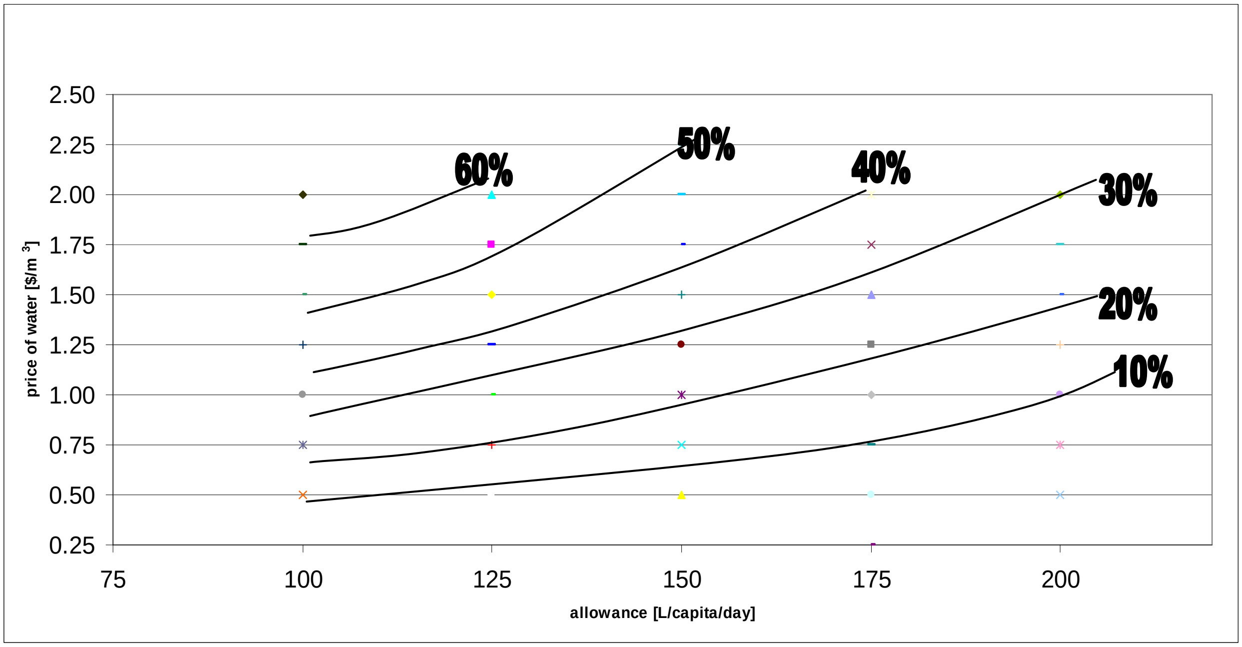

Figure 7: Influence of the allowance and price on demand reduction for the Saudi Arabia model. Lines represent equal percentage reduction from an initial demand computed for a price of $0.25/m^3

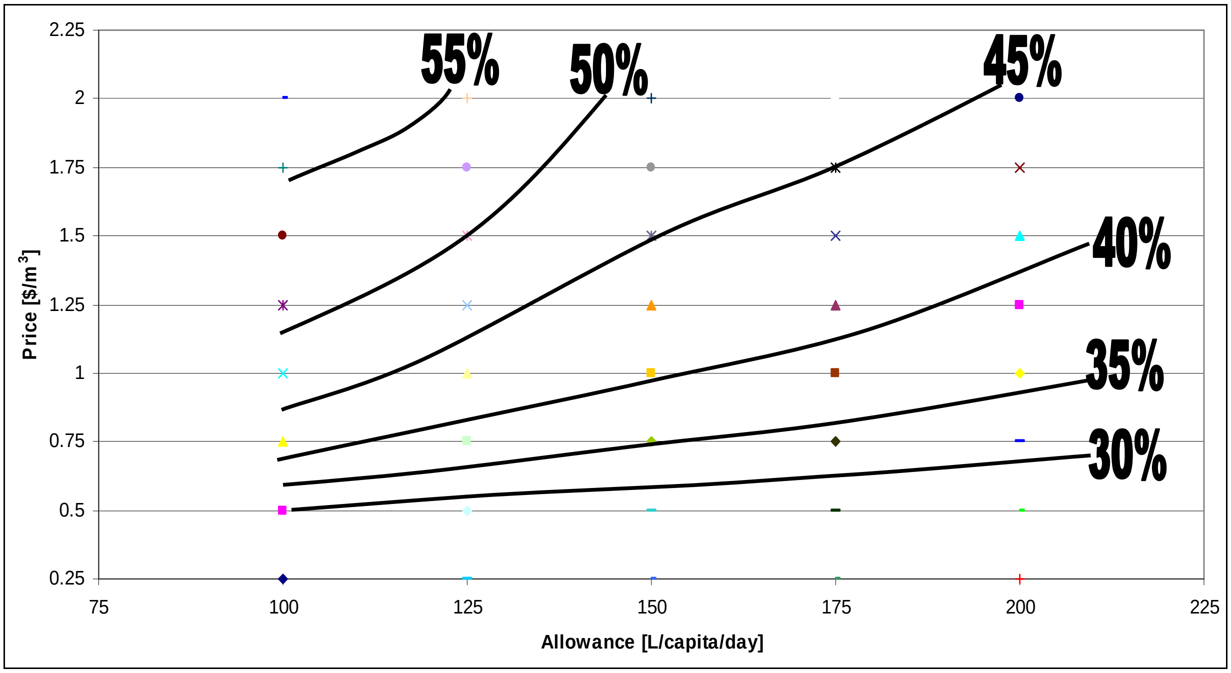

Figure 8: Computed distribution of water demand for a free water situation

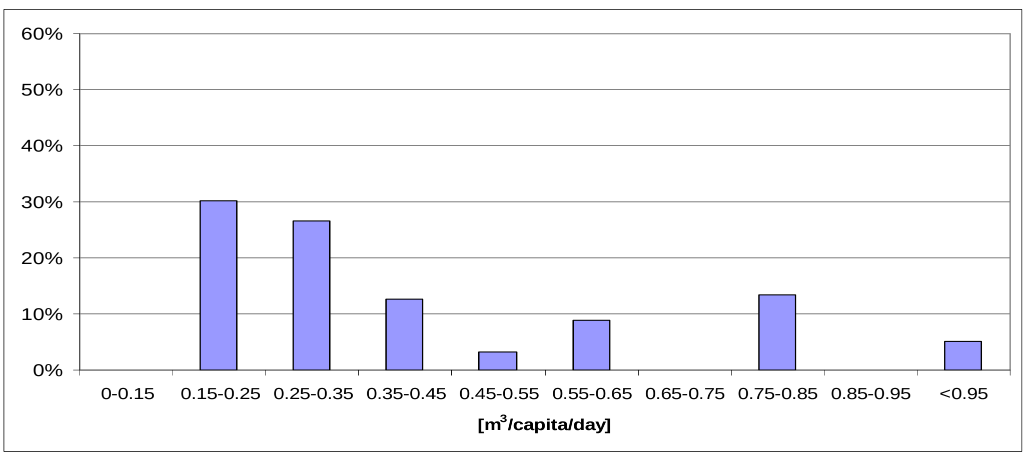

Figure 9: Computed distribution of water demand for a price of $\$1/m^3$

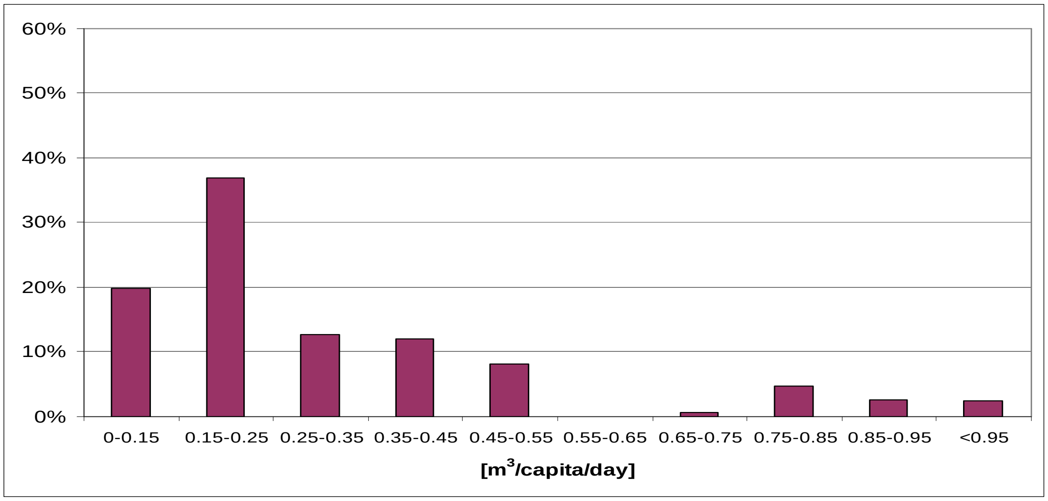

Figure 10: Computed distribution of water demand for a price of $\$2/m^3$

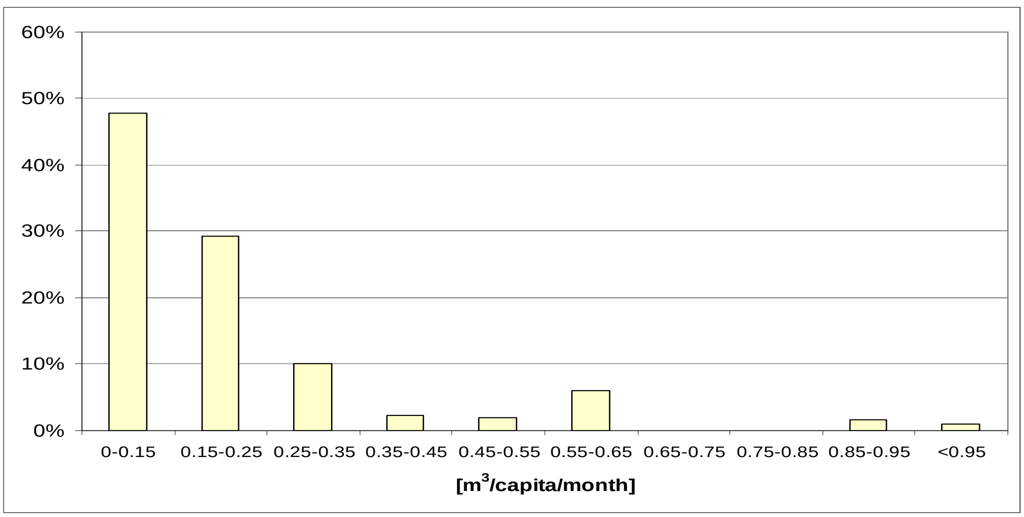

Figure 11: Contribution of the consumers and of the government to the cost of producing water computed for an initial 150 L/capita/day (4,5 m3/capita/month) allowance using the Saudi Arabia model

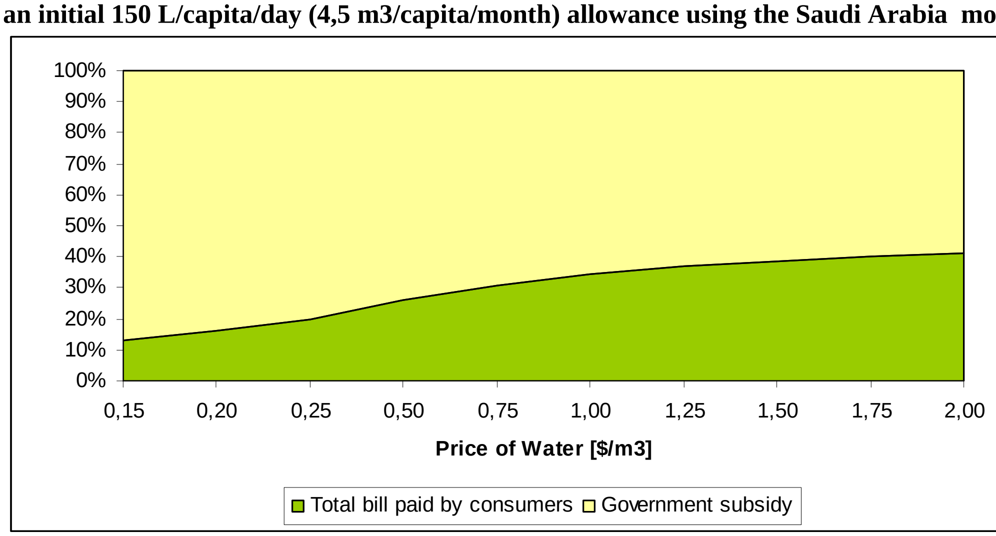

Table 1: Price elasticities from previous studies of residential water demand

Authors	Form	Study area	Price variable	Price Elasticity
Foster and Beattie (1980)	Exponential	USA	AP	-0.35 to -0.76
Billings (1982)	Lin/Log	Tucson, Arizona	MP & D	-0.66/-0.56
Chicoine and Ramamurthy (1986)	Linear	Illinois	MP (AP)	-0.6 on MP
Nieswiadomy and Molina (1989)	Linear	Denton, Texas	MP & D	-0.86
Griffin and Chang (1990)	Linear	USA	AP	-0.16 to -0.37
Riazaiza (1991)	Logarithmic	Saudi Arabia	AP	-0.36
Hansen (1996)		Denmark		-0.10
Renwick and Archibald (1997)	Linear	California	MP & D	-0.33
Hoglund (1997)	Linear	Sweden	MP & AP	-0.20 on AP
Dandi et al. (1997)	Linear	Australia	MP & D	-0.63 to -0.77
Renwick, Green, and McCorkle (1998)	Logarithmic	California	MP & D	-0.16 to -0.21
Nauges and Thomas (2000)	Linear	France	AP (&MP)	-0.22
Ayadi et al.(2003)	Logarithmic	Tunisia	AP	-0.17

Table 2: Comparison of GDP

Population	GDP per capita	Source
USA	$36.121	US Census Bureau, 2001 (current prices)
Kuwaiti	$21,300	World Factbook, 2005 (CIA Website)
Non-Kuwaiti	$10,650	

Table 3: United States household income

Income($1000/month)	[%]
Under 1.25	15.8
1.25-2.92	25.6
2.92-6.25	36
6.25-12.5	17.9
Over 12.50	4.6

Table 4: Assumed income distribution for Kuwait

Percent of households [%]	Average income ($1000/month)	
	Kuwaiti	Non-Kuwaiti
15.8	0.51	0.26
25.6	1.21	0.60
36	2.66	1.33
17.9	5.44	2.72
4.6	11.13	5.56

Table 5: Household size distribution for Kuwait

Type of Household	Kuwaiti	Non-Kuwaiti	Total
1 member	14,710	96,578	111,288
2-5 members	45,989	80,945	126,934
6-9 members	38,039	21,696	59,735
10+ members	40,645	10,309	50,954
Total private	139,383	209,528	348,911
Non-private	--	85,640	85,640
Total	139,383	295,168	434,551

(Adapted from National Bank of Kuwait 1999)

Table 6: Assumed household size distributions used in simulations

Household Size	% of Kuwaiti households	% of Non-Kuwaiti households
1	11%	46%
2-5	33%	39%
6-9	27%	10%
>10	29%	5%

Table 7: Some coefficient values used for adapting the California Model

Coefficient	Description	California value	Kuwait value
β_0	Intercept	2.61	2.35
β_1	MP	-0.16	-0.16
β_2	Difference variable	-0.01	-0.01
β_3	Income	0.25	0.5

Table 8: Coefficients changed in order to adopt the Tunis Model for Kuwait

		Kuwait		Tunis	
Coefficient	**Description**	**Lower Block**	**Higher block**	**Lower Block**	**Higher block**
α_0	Intercept	1.25	1.8	3.1	8.65
γ_0	Intercept	1.525	2.035	3.27	9.84

Table 9: Marginal price elasticities calculated in the simulations compared to the original studies

Model	At price [$/m^3]	Constant price schedule	Constant price schedule with initial allowance	Original study
California	0.75	-0.16	-0.13	-0.16 to -0.2
Australia	0.75	-0.89	-0.24	-0.63 to -0.77
Tunisia	1	-0.33	-0.27	-0.1 to -0.4 (AP)
Saudi Arabia	1	-0.78	-0.26 (MP); -0.78(AP)	-0.36 (AP)
Stone-Geary-Spain	1	-0.23	-0.23	-0.1

* AP – average price elasticities

Table 10: Reduction in demand simulated for Kuwait at a marginal price of $1/m^3 from an initial price of $0.25/m^3

Model	% reduction without allowance	% reduction with 150 L/capita/day allowance
California	19%	17%
Tunisia	45%	40%
Saudi Arabia	66%	41%
Australia	57%	21%
Spain	41%	40%