Residential water price elasticity and full water cost estimation according to the European Water Framework Directive

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Abstract

The relationship between water abstraction and water availability has turned into a major stress factor in the urban exploitation of water resources. There is a wide recognition nowadays that there is a need for strategies for the sustainable use of water resources and water demand management.

In the city of Volos-Greece the number of water counters has been almost tripled during the last 3 decades. The fact that water sources have remained stable has created a derangement of water balance. In order to evaluate various aspects of current water policy, investigate the perspectives of water saving, explore new approaches toward sustainable water management in the water supply sector and evaluate water price elasticity, a survey has been performed recently in the city of Volos, concerning the residential sector.

The influence of some selected variables is examined, residential water demand curve is calculated using the fixed-effects and random effects model and elasticity with respect to marginal and difference price is estimated. Estimations of future water demand under different pricing policies are also performed. Full water cost in the city of Volos is finally estimated and essential conclusions concerning water pricing and public participation evoke.

1. Introduction

Residential or else domestic water use refers to water for household needs such as drinking, food preparation, bathing, washing clothes and dishes, flushing toilets and watering lawns and gardens.

It is obvious that problems connected with water resources and their exploitation in combination with the general environmental problems have been continuously increased. The situation is expected to be sharpened still more in the near future due to the impacts from climate change (reduction of rainfalls and intensity of extreme meteorological phenomena). Besides, in Greece, water resources management is based in most regions in the management of its natural offer taken water demand for granted. This confrontation is ineffective, and leads with mathematic certainty to an economic and environmental impasse, having as a main characteristic the exhaustion of water resources. The causes of crisis of water differ from country to country and from region to region depending on natural, economic, social and political conditions that prevail in each study area. However, the more systematic approach could recognize the existence of common characteristics.

What is necessary today is a more viable, friendly to the environment approach, which is the so called water demand management.

In European level, the European Water Framework Directive 2000/60 sets the political and institutional framework for the protection and integrated management of waters in level of river basin district with the active public participation. According to article 9, Member States owe to take into consideration the principle of recuperation of cost of services of water, included the cost for the environment and the natural resources as well as the economic analysis that is carried out according to the ‘polluters pay’ principle. Up to 2010, Member

States should ensure that their water pricing policies will provide suitable motives to users in order to use water resources effectively and in consequence contribute to the achievement of environmental objectives of European Directive. Simultaneously, the economic analysis for each type of water uses (industry, households and agriculture) is forecasted. Finally, article 14 of the European Water Framework Directive is focused on the active involvement of all interested parties in all levels of water resources management. This article is important in the context of demand management as water conservation programmes are unlikely to succeed in the absence of public involvement and support. The emphasis on active involvement, described in the supporting documentation as 'a higher level of participation than consultation' has the potential to initiate a culture change where the public become part of the solution, as opposed to their water use being the problem (Butler, 2006).

The confrontation of water not only as social, but also as an economic good, the definition of the social parameters that shape its demand, the exploitation of effective economic tools and the full cost water pricing are subjects of the present research.

As each region has its own characteristics and the factors that shape water demand differ, an integrated methodology is applied in the region of Volos, Greece.

2. The study area

The research took place in the wider region of the city of Volos, Greece. Volos is the capital of the prefecture of Magnesia with a population of approximately 120,000 (Fig 1). The Municipal Water Utility of the city of Volos is responsible for the urban water supply in the city of Volos with an estimated average water consumption of about 350 liters per counter per day.

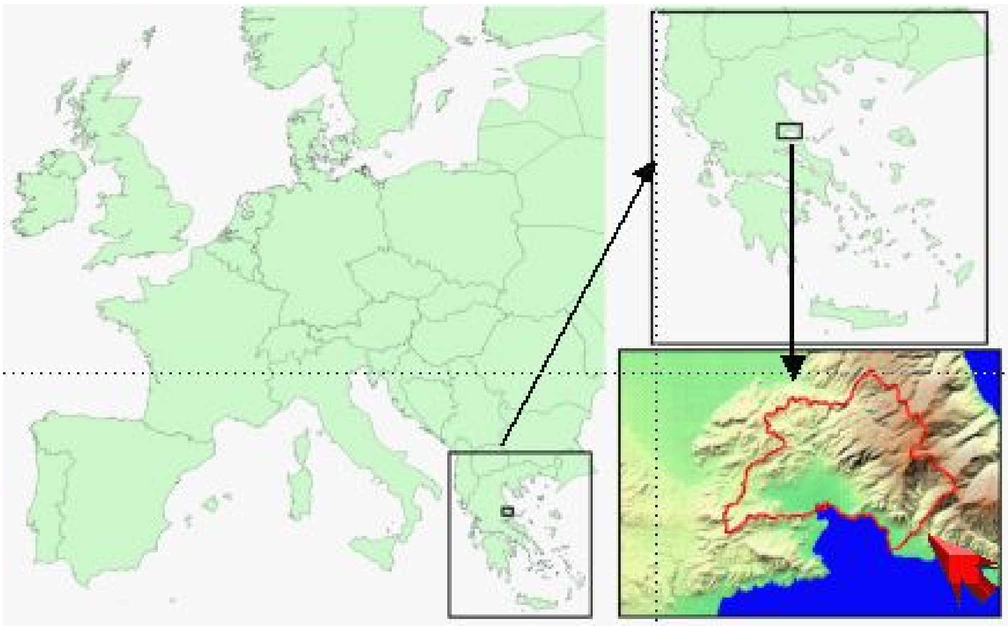

Figure 1: The study area: Volos, Greece.

The broader study area is divided into four main sectors. Sectors 1, 2 and 3 cover the municipality of Volos, whereas sector 4 the municipalities of Nea Ionia and Esonia. The whole research is based on the data retrieved from a field survey which includes questionnaires through face-to-face interviews. From the 112 questionnaires which were collected, 100 were considered to be completely filled in and suitable for further use. Probability sampling was the method applied and the percentage of each sector's participation in the sample was calculated according to information retrieved from the National Statistical Service of Greece.

The questionnaire consists of three parts. In the first part the general social characteristics of the sample are being inquired. The second part includes water consumption issues, as well as consumers' evaluation and grading of factors which eventually affect water consumption and parameters which contribute to water saving. The third part examines both consumers' willingness to be informed and take part in water conservation programs and their willingness to pay in order to improve the services provided by the Municipal Water Utility.

3. Main survey findings

3.1. Water quality and quantity issues

The consumers' sensitivity and concern regarding water problems is outstanding, since 75% believe that serious water problems will arise in the near future in the wider region of Volos, Greece. In addition, only 1 out of 4 respondents find the quality of tap water satisfactory. This could be explained by the old and poorly maintained supply infrastructure, which creates problems both in the taste and odour of tap water, rather than in the actual water quality.

Half of the consumers believe that the main water problem lies in water quality and not in water quantity. 29.30% considers that a complex problem of availability and quality exists, 15.12% declares that there is no important water problem, while few are those who answered that the main problem is sufficiency rather than pollution. It is obvious that the respondents underline water quality problems that are strongly connected with health risks and seem to underestimate water availability problems.

3.2. Water pricing issues

The uniform rate with a fixed monthly service charge corresponding to a minimum water consumption of 5 m^3/month was the pricing policy for the residential sector that had prevailed in the city of Volos till 1985. The next years, the residential customers were being charged based on a three-block rate (1985-1991) and on a four-block rate structure (1991-1997). Since then, the rate structure has included five water brackets combined with a fixed service charge of 15 m^3/trimester.

Although water price has considerably increased (especially the increase for high consumers reaches up to 58%), almost half of the sample is willing to contribute financially to the improvement of water services provided by the Municipal Water Utility and the majority of them would accept an amount of up to 30€ annually, whereas only very few would consent to a higher amount (from 45€ till 300€ annually). On the other hand, 49% of the respondents who are not willing to pay extra for service improvements reveals the low reliability of the utility's services.

The high percentage (57%) that declares that the contribution of the water bill to their family income is less than 1% enhances the prevailing opinion that water is a social good and should not be confronted as an economic one.

3.3. Awareness and participation in water conservation programs

Consumers' willingness to be informed on programs and water conservation services reaches a very high level. The overwhelming majority of consumers (90%) wish to be informed by the Municipal Water Utility of the city of Volos on the water supply problems of the city as well as on water related issues.

Therefore, the Water Utility should take advantage of their willingness, in order to communicate with the consumers and promote its future plans. As far as the way of information is concerned most of them wish to be informed directly by the Water Utility through a special edition dispatched together with the water bill. Local media (radio, TV, newspapers) seem to play also a very important role in informing the public, whereas magazines and other means (i.e. internet) are considered to be less important.

Moreover, 87% of the sample would be willing to take part in water conservation programs. This conclusion is of tremendous importance, since before applying any water conservation program, one should check the possibility of failing to achieve the goal, which is the decrease in water demand.

4. Residential water demand model

Many studies have been performed concerning modeling of residential water demand. Researchers have defined water demand in different ways according to the explanatory variables they select and their mathematical relationship to water demand.

A basic and non-complicated equation that can describe some observations (y), which depend on a set of variables (x), takes the following form [1].

$$y_{it} = a + \sum_{k=1}^{K} \beta_k x_{kit} + v_i + u_{it} \qquad i = 1, 2, \ldots, N \qquad t = 1, 2, \ldots, T \qquad [1]$$

where:

y : the dependent variable in observation i at time t

x_{kit} : the vector of specific selected variables

α, β_k : coefficients to be estimated

v_i : the unexpected regime of the dependent variable

u_{it} : the error term.

Time series data of 3-month water consumption levels from 1997 to 2005 are collected from databases of Water Utility of the city of Volos, while raw data concerning rainfall and temperature are retrieved from meteorological stations in the city of Volos.

Marginal price and the difference variable are used and both of them are adjusted by the consumer price index (CPI).

Three variables are selected from the initial survey in the form of cross section data and are inserted in the model as dummy variables (variables with only two values, zero and one). The first one is used in order to quantify the consumers that use water for outdoor purposes, the second defines the educational level of consumers while the third their financial situation.

The data used in the model have the form of panel data, combination of cross-section and time series. In order to derive direct price elasticity estimates of demand for water a log transformation of Equation 1 is used. Estimations are performed using fixed-effects and random effects (GLS) models.

By running the Hausman test, which checks the more efficient model against the less efficient, a significant P-value was calculated, showing that fixed-effects model is the appropriate one and is used for the interpretation of results.

The own price elasticity is negative and less than unity in absolute value, so the water demand in the city of Volos is relatively inelastic and water consumption changes less than proportionately with price. A 10% increase in price can lead to the reduction of water consumption to 9.53%. The high value means that the current water policy can act as an incentive to water conservation. The model's coefficient for temperature (T) is 0.02, meaning positive in sign and statistically significant (P-value<.05). It has the expected sign as a 10%

increase in temperature values, leads to a small increase of 0.2% in water consumption. However, the coefficient of precipitation (R) is 0.19 and is estimated with the opposite sign than expected.

In the next figure the estimated water demand curve is presented using both fixed and random effects model.

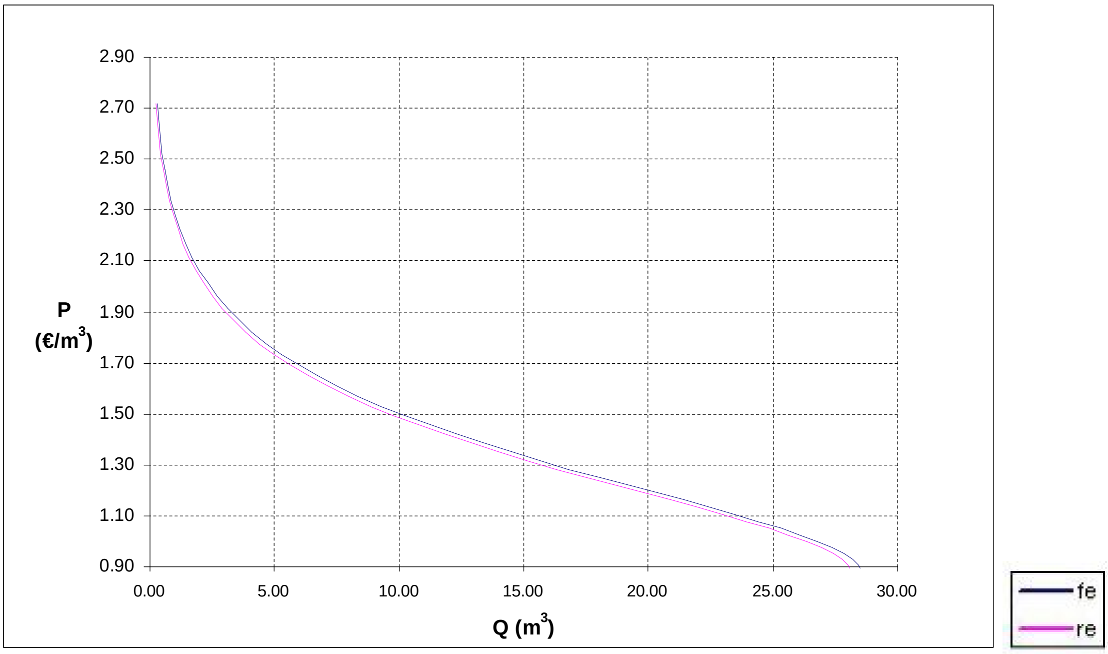

Figure 2: Residential water demand curve in the city of Volos, Greece.

The maximum water consumption value Q is respectively 28.5 m^3 and 28.1 m^3 per trimester. These consumption levels belong to the mean level of the second bracket of the existing pricing scheme in the city of Volos (low margin: 16 m^3 and high margin: 38 m^3), meaning that only the first two brackets are actually used by the majority of consumers.

5. Future water demand levels

The system "IWR-MAIN Water Demand Analysis Suite" is a frequently used tool for prediction of future water demand in the urban sector. According to the needs and the available data of each case, four statistical models exist for forecasting water consumption. In this study, the appropriate model turned to be the Build Forecasting Model.

Residential water consumption *Q* for month *m* and for the year of prediction *y* is given by the equation:

$$Q_Y = N \cdot q^* \cdot \left(\frac{X_{i,Y}}{X_{i,b}} \right)^{\beta_i} \cdot d_m \qquad [2]$$

where:

N : the number of water measurement devices
q^* : the specific consumption per capita per day in the base year
d_m : the number of days in each month
$X_{i,Y}$: the value of variable i in the year of prediction Y
$X_{i,b}$: the value of variable i in the base year b
β_i : the elasticity of variable i

The base year used is 2005 and projections of water consumption levels are made for years 2005 and 2017 under eight different scenarios of water pricing policies. The eight different water pricing scenarios include:

- Scenario 1: price of water is stable from 2005 to 2017
- Scenario 2: increase in water price so that the real price of water will remain stable and equal to the real price of water in 2005
- Scenario 3: a 5% increase of the real price of water every four years (base year 2005)
- Scenario 4: a 10% increase of the real price of water every four years (base year 2005)
- Scenario 5: a 15% increase of the real price of water every four years (base year 2005)
- Scenario 6: price of water stable from 2005 to 2009 and change in next periods so as the real price increases 5% every four years
- Scenario 7: price of water stable from 2005 to 2009 and change in next periods so as the real price increases 10% every four years
- Scenario 8: price of water stable from 2005 to 2009 and change in next periods so as the real price increases 15% every four years.

It is evident that there are notable differences in water demand levels in relation to the implementation of different water pricing policies (Table 1). Important increases in water consumption levels appear under scenario 1. Under scenario 4, 5, and 8 where the real price of water increase 10% or 15% every four year, there is a decrease in water consumption. Under scenario 2, 3, 6 and 7, where increases are lower, water demand increases at lower scales in relation to the increase noticed under scenario 1.

	2005	2009	2013	2017
Scenario 1	8,284,507	9,981,764	11,965,688	14,278,321
Scenario 2	8,284,507	8,921,326	9,558,145	10,194,964
Scenario 3	8,284,507	8,516,577	8,711,229	8,870,778
Scenario 4	8,284,507	8,148,391	7,974,308	7,769,303
Scenario 5	8,284,507	7,811,455	7,328,468	6,844,825
Scenario 6	8,284,507	8,921,326	9,124,504	9,291,622
Scenario 7	8,284,507	8,921,326	8,730,036	8,505,603
Scenario 8	8,284,507	8,921,326	8,369,050	7,816,733

Table 1: Fluctuations of total water consumption (m^3) for years 2005-2017 under scenarios 1-8

6. Estimation of full cost pricing

Article 9.1 of the Water Framework Directive 2000/60 refers to the recovery of the full cost of water services and clarifies the cost components that should be included in the full costs. The components of full water cost include (WATECO, 2003 & Rogers, 1998):

- The **supply cost** that includes the costs of investments, operation and maintenance, labour, administrative costs and other direct economic costs.
- The **resource cost** that represents the loss of profit because of the restriction of available water resources.

- The **environmental cost** that represents the cost from the damage on the environment and aquatic ecosystems caused by the water uses and services.

The estimation of the supply cost is rather easier, but requires the choice of suitable values for all the parameters as investments lifetime, discount rates, value of existing infrastructure and depreciation methods. General taxes and subsidies are not included, while the environmental taxes are included in the environmental cost since the constitute part of this cost.

An assessment of the resource cost is based on the estimation of the water price before and after the reduction of water resources. Figure 3 outlines the estimation procedure. The demand curve should be available as well as the availability of water resources.

When the water demand for all the uses is covered adequately, the resource cost is zero. The resource cost increases considerably when water shortages occur for certain water uses. The resource cost for a specific use could be assessed on the basis of the foregone economic benefits from competitive water uses.

The environmental cost can be assessed using several methods such as:

- Market methods
- Methods based on costs
- Preference methods
- Willingness to pay methods.

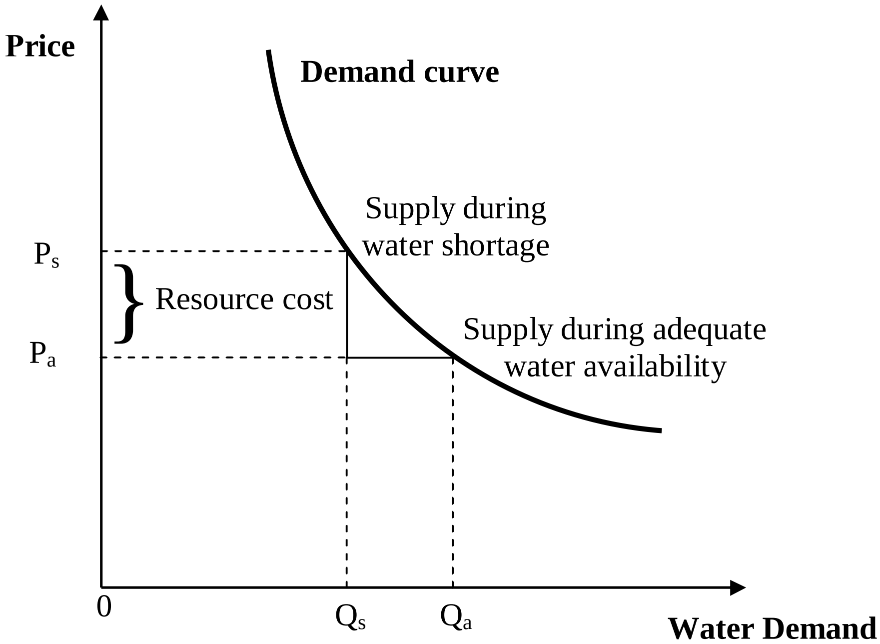

Figure 3: Estimation of the water resource cost.

6.1 Direct costs

Generally, direct costs are the costs brought about by providing and administering water services. In this context, they can be broken down in a number of cost elements:

- **Annual Equivalent Capital Costs (AEC)**
  - New investment expenditures and associated costs.

- Depreciation of existing infrastructure, representing an annualized cost for replacing existing assets in the future.
- Cost of capital, representing the opportunity cost of capital.

- **Operational and Maintenance Costs (OMC)**, defined as all costs incurred to keep a facility running and for maintaining existing (or new) assets in good functioning order until the end of their useful life.

- **Administrative and Other Costs (AOC)** related to water resource management.

DC = AEC + OMC + AOC [3]

In order to estimate the direct cost, financial data (balance sheet) and water production and consumption data was used, derived from the Water Utility of Volos.

It must be noticed that the internal environmental cost is included in the direct cost, which is paid by the consumers through the sewerage fee in the water bill of the Water Utility. The sewerage fee is 0.62 €/m^3 consumed water. Table 2 shows the calculated direct costs for the year 2005:

Debit interests and other charges	316,506
Depreciation of fixed assets	3,488,547
Annual Equivalent Capital Costs (AEC)	**€3,805,053**
Cost of sales (including capital costs)	12,190,637
Cost of capital	-3,805,053
Operational and Maintenance Costs (OMC)	**€8,385,584**
Administrative expenses	2,398,757
Extraordinary and non-operating expenses and losses	184,211
Administrative and Other Costs (AOC)	**€2,582,968**
Direct Costs: DC = AEC + OMC + AOC =	**€14,773,605**

Table 2: Direct Costs for the year 2005.

The Direct Costs (DC) for the year 2005 are €14,773,605. The water consumption for the same year is 9,714,426 m^3. Thus, the Total Direct Costs per consumed m^3 of water are:

DC = €14,773,605 / 9,714,426 m3 = 1.52 €/m^3

The Direct Costs (DC), in the city of Volos, constitutes of the direct costs for residential use (RDC) and the direct costs for industrial use (IDC), since the Water Utility of Volos is responsible not only for the 3 municipalities (Volos, Nea Ionia and Esonia), but for the two industrial zones of Volos.

The Residential Direct Costs (RDC) are €11,988,387 and correspond to the 81.15% of the total Direct Costs (DC), while the annual residential consumption for the year 2005 is 8,284,911 m^3. The Residential Direct Costs per consumed m^3 are:

RDC = €11,988,387 / 8,284,911 m^3 = 1.45 €/m^3.

The Industrial Direct Costs (IDC) are €2,785,219, while the annual industrial consumption for the year 2005 is 1,429,515 m^3. The Residential Direct Costs per consumed m^3 are:

$$IDC = €2,785,219 / 1,429,515\ m^3 = 1.95\ €/m^3.$$

The difference between the Residential (1.45 €/m^3) and the Industrial Direct Costs (1.95 €/m^3), can be attributed to the industrial water pipe network; its length and its diameters are larger than those of the residential network.

6.2 Resource costs

Resource costs are defined as the costs of foregone opportunities, which other uses suffer due to the depletion of the resource beyond its natural rate of recharge or recovery (e.g. linked to the over-abstraction of groundwater*)* (WATECO, 2003).

Resource costs are defined in this information sheet as the opportunity costs of using water as a scarce resource in a particular way (e.g. through abstraction or wastewater discharge) in time and space. They equal the difference between the economic value in terms of net benefits of present or future water use (e.g. allocation of emission or water abstraction permits) and the economic value in terms of net benefits of the best alternative water use (now or in the future) (Drafting Group ECO2, 2004).

In the city of Volos, as mentioned before, there are two competitive water uses: the residential and the industrial use. An assessment of the resource cost is based on the estimation of the water price before and after the reduction of water resources. Figure 3 outlines the estimation procedure. The demand curve should be available as well as the availability of water resources.

The demand curve of the residential use in the city of Volos has already been estimated, as shown in Figure 2. The balance prices before the reduction of the water resources (water availability conditions) can be estimated by the maximisation of the consumption in the water demand curve, namely the consumption in water availability conditions is:

$$Q_a = 28.48\ m^3/\text{trimester}$$

The balance prices after the reduction of the water resources (water shortage conditions) will be estimated using an alternative scenario in order to estimate the future water needs in water shortage conditions.

The scenario, which was created by using IWR-MAIN Build Forecasting model, is a combination of simultaneous implementation of water pricing policies and extreme weather conditions. Explicitly, for the years 2005-2017, the scenario incorporates:

- a 25% increase of the real price of water every four years (base year 2005)
- a 30% decrease of rainfall and 15% increase of temperature for the same time period.

By running the model, according to equation [2], the following results arose:

	2005	**2009**	**2013**	**2017**
Consumption (m^3)	8,284,507	7,142,120	6,340,423	5,663,909

Table 3: Estimation of future water consumption levels under water shortages scenario

According to this extreme scenario, there is a dramatic decrease (31.63%) of the water consumption from 2005 to 2017. The annual water consumption for the year 2017 will be:

$$Q_{2017} = 5{,}663{,}909 \text{ m}^3/\text{yr}.$$

The expected number of water counters for the year 2017 will be 80,047. So, the average annual consumption per counter will be:

$$Q_{aver} = 5{,}663{,}909 / 80{,}047 = 70.76 \text{ m}^3/\text{yr}$$

and the average trimester consumption per counter will be:

$$Q_{aver} = 70.76 / 4 = 17.69 \text{ m}^3/\text{trimester}$$

Hence, the consumption in water shortage conditions is: $Q_s = 17.69$ m^3/trimester. By inserting in the demand curve the values of water consumption, the values of water price can be calculated in water availability and water shortage conditions (Figure 4):

Water availability conditions: $Q_a = 28.48$ m^3/trimester $\rightarrow P_a = 0.887$ €/ m^3
Water shortage conditions: $Q_s = 17.69$ m^3/trimester $\rightarrow P_s = 1.260$ €/ m^3

Finally, the resource costs (RC) are:

$$RC = Ps - Pa = 1.260 - 0.887 = 0.373 \text{ €/m}^3.$$

By adjusting the cost above with the consumer's price index (CPI), the resource costs for the year 2005 are:

$$RC = 0.49 \text{ €/m}^3.$$

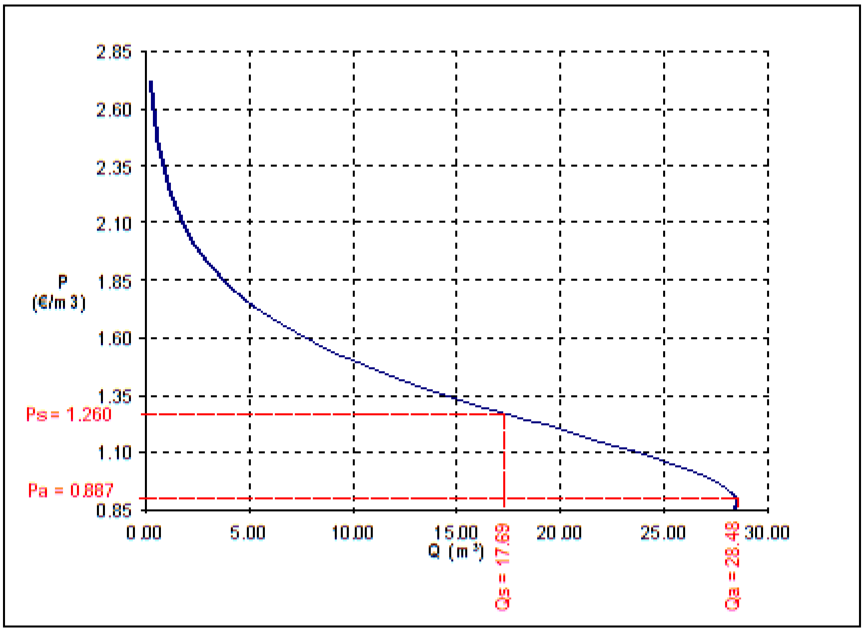

Figure 4: Water price in water availability and water shortage conditions.

6.3 Environmental costs

Environmental costs are defined as representing the costs of damage that water uses impose on the environment and ecosystems and those who use the environment (e.g. a reduction in the ecological quality of aquatic ecosystems or the salinisation and degradation of productive soils) (WATECO, 2003).

Another important point is the distinction between internal and external environmental and resource costs. Internal costs refer to costs, which are part of the economic system related to specific water use, whereas external costs remain outside the economic system. Hence, internal or internalised environmental and resource costs exist, if economic costs as a result of specific water use are compensated, financially or otherwise. On the other hand, if these economic costs remain uncompensated, external environmental and resource costs occur.

In environmental economics, various models and techniques have been developed to measure the value people attach to natural resources and the goods and services these resources provide. Environmental values are measured in money terms through the concept of individual willingness to pay (WTP) or willingness to accept compensation (WTAC) in order to make them commensurable with other market values. Of these two, the WTP approach has become the most frequently applied and has been given peer review endorsement through a variety of studies (Arrow et al., 1993).

6.3.1 Utility models

In willingness to pay (WTP) studies, where the utility-theoretic approach is performed (Hanemann, 1984) respondent's income is often collected in terms of bracketed form or income categories, through a question identifying into which of *n* income categories the individual's income falls. In these studies, the income variable is usually imputed as a continuous variable by using:

- the midpoint of the income categories
- the category number $c = 1, 2, ..., n$, with *1* representing the first (lowest) income category, *2* representing the second income category, etc.
- *n* dummy variables in which $d_i = 1$, if $c = i$ to represent the various income brackets/categories.

After specifying the income variable, the choice of the functional form of the utility function is critical for the econometric model.

Table 4 presents nine potential model specifications. The columns divide the models depending on the way the income variable is being processed; the rows of the table divide the models in terms of their functional specification. Most Contingent Valuation studies treat the income as a continuous variable, typically using dummy variables d_i, imputed income y, or the income category c, and such models are presented in columns 1, 2 and 3 (Aiew et al., 2004).

The models in the first row of Table 3 assume that indirect utility is linear in income and the bid, as is true for most specifications, in the linear models the marginal effect of a change in income is allowed to differ from the marginal effect of a change in the bid. In the remaining rows the bid b enters logarithmically into Δv, meaning that these specifications cannot be derived from a specification of the indirect utility functions. In the remainder of this paper, the WTP estimates obtained from each of these models are compared.

Functional form	Using income as dummy variables	Using median of income categories	Using income as category numbers
Linear	Model 1	Model 2	Model 3
	$\Delta v = \alpha_0 + \beta_0 b + \sum a_i d_i + \beta_i d_i b$	$\Delta v = \alpha_0 + \beta_0 b + a_1 y$	$\Delta v = \alpha_0 + \beta_0 b + a_1 c$
	$WTP = -\dfrac{\alpha_0 + \sum \alpha_i d_i}{\beta_0 + \sum \beta_i d_i}$	$WTP = -\dfrac{a_0 + a_1 y}{\beta_0}$	$WTP = -\dfrac{a_0 + a_1 c}{\beta_0}$
Log of net income ratio	NA	Model 4	NA
		$\Delta v = (a_1 - \alpha_0) + \beta_0 ln\left(\dfrac{y-b}{y}\right)$	
		$WTP = y\left(1 - \exp\left(-\dfrac{a_1 - a_0}{\beta_0}\right)\right)$	
Log bid	Model 5	Model 6	Model 7
	$\Delta v = \alpha_0 + \beta_0 lnb + \sum(\alpha_i d_i + \beta_i d_i \ln b)$	$\Delta v = \alpha_0 + \beta_0 lnb + a_1 y$	$\Delta v = \alpha_0 + \beta_0 lnb + a_1 c$
	$WTP = exp\left(-\dfrac{a_0 + \sum a_i d_i}{\beta_0 + \sum \beta_i d_i}\right)$	$WTP = exp\left(-\dfrac{a_0 + a_1 y}{\beta_0}\right)$	$WTP = exp\left(-\dfrac{a_0 + a_1 c}{\beta_0}\right)$
Log bid and log income	NA	Model 8	Model 9
		$\Delta v = \alpha_0 + \beta_0 lnb + a_1 lny$	$\Delta v = \alpha_0 + \beta_0 lnb + a_1 lnc$
		$WTP = exp\left(-\dfrac{a_0 + a_1 \ln y}{\beta_0}\right)$	$WTP = exp\left(-\dfrac{a_0 + a_1 \ln c}{\beta_0}\right)$

Table 4: Utility function models.

6.3.2 Estimated WTP values of the models

The respondent's income was sorted in four predefined categories found in the questionnaire. The household income categories are the following:

- < €6,000
- €6,000 - €12,000
- €12,000 - €20,000
- > €20,000

Table 5 presents the estimated willingness to pay functions of the models exhibited in Table 4. The estimated WTP value (€/year) is 39.98 for models 1-3 (linear models) and 20.52 for models 5-9 (logarithmic models). The applied method is linear regression using the statistic software Stata.

Model	Willingness to pay functions
1	$WTP = 18.0000 + 0.0000*d_1 + 9.1875*d_2 + 8.1429*d_3 + 57.3333*d_4$
2	$WTP = -8.83085 + 0.0035*y$
3	$WTP = -13.06373 + 19.3232*c$
4	*NA*
5	$lnWTP = 2.6229 + 0.0000*d_1 – 0.0026*d_2 + 0.2513*d_3 + 1.1226*d_4$
6	$lnWTP = 1.8967 + 0.0001*y$
7	$lnWTP = 1.8497 + 0.4268*c$
8	$lnWTP = -5.7524 + 0.9284*lny$
9	$lnWTP = 2.2156 + 0.8693*lnc$

Table 5: Willingness to pay functions.

where:

d_1, d_2, d_3 and d_4	:	the dummy variables of income
y	:	the income variable
c	:	the income category variable
WTP	:	willingness to pay

6.3.3 Estimated Environmental Cost

Consumers' willingness to pay represents the environmental costs of water. Environmental costs consist of the environmental damage costs of the degradation and depletion of the aquatic ecosystem caused by a particular water use (e.g. water abstraction or the emission of pollutants) (Drafting Group ECO2, 2004), according to the Water Framework Directive 2000/60/EU.

The environmental costs are, as mentioned above, rather complicated and can be assessed by using one of the willingness to pay methods, such as the Contingent Valuation Method (CVM), which is based on the estimation of the consumers' willingness to pay for the preservation of an environmental good (water in our case) through the use of questionnaires.

The Environmental Costs (EC) can be calculated, since consumers' willingness to pay (WTP) is already estimated and the water consumption is known: the estimation of willingness to pay is WTP = 39.98 €/yr. The total number of counters in the year 2005, when the survey took place, is 65,046. Only 51% of them, approximately 33,174 households are willing to pay extra for service improvements.

Hence, the environmental costs (EC) of water are:

$$EC = 39.98 \text{ €/yr} * 33,174 = 1,326,297 \text{ €/yr}.$$

The total water consumption for residential use in the city of Volos, for the year 2005, is 8,284,911 m^3/yr.

Finally, the environmental costs (EC) per cubic meter of consumed water are:

$$EC = 1,326,297 \text{ €/yr} \;/\; 8,284,911 \text{ m}^3\text{/yr} = 0,16 \text{ €/m}^3.$$

6.4 Full Cost Recovery

Article 9.1 of the Water Framework Directive 2000/60 refers to the recovery of the full cost of water services and clarifies the cost components that full water costs should include:

- The direct costs (DC)
- The resource costs (RC)
- The environmental costs (EC)

In the city of Volos, the full water costs (FC) for residential use for the year 2005 are:

$$FC = DC + RC + EC = 1.45 + 0.49 + 0.16 = 2.10 \text{ €/m}^3.$$

The water price for the year 2005, according to the 2nd block tariff, is 1.12 €/m^3. As we can see water pricing of the Water Utility does not comply with the WFD demand for full cost recovery. The Cost Recovery Rate (CRR) is:

$$CRR = 1.12 / 2.10 = 0.53 = 53\%.$$

This means that the Water Utility of Volos should raise the price of water (1.12 €/m^3) by 87% in order to soundly meet the full water recovery (2.10 €/m^3) for residential use.

7. Conclusions

It is evident that Water Utilities face the challenge of developing new water policies by adopting advanced technologies for demand management through a series of incentives, reuse of treated wastewater, installation of water saving and conservation equipments, consumer's awareness and education while simultaneously should introduce changes in pricing procedures and cost recovery in order to comply with the principle of full cost pricing, referred to the Water Framework Directive.

The high water price elasticity in the city of Volos, Greece, indicates that water pricing strongly contributes to water conservation. After implementing different water pricing scenarios, it was proved that the most effective scenarios in the future decrease of water demand are those that suggest either 10% or 15% increase in the real price of water every four years. Moreover, in order to fulfill the requirements of Article 9 of Water Framework Directive for full cost recovery, Water Utility should raise water price by 87%.

In addition, water demand curve present that only the first two brackets are actually used by the majority of consumers, as the maximum consumption level belongs to the mean level of the second bracket of the existing pricing scheme in the city of Volos (low margin: 16 m^3 and high margin: 38 m^3). Thus, a further division of this bracket is recommended, including simultaneously higher prices in each block, which will provide consumers a pure financial incentive to conserve water.

More billing periods are also suggested, as users who are more frequently billed might be expected to understand better the tariff structure and the relation between the use and the size of the bill.

Finally, as water conservation programs are widely accepted by the public, efforts of implementation of such programs should be launched. Public's contribution as well as the general environmental education of consumers is considered of great importance for the successful implementation of demand management programs. Campaigns should be worked out in order to actuate consumers towards low water consumption technologies and generally a demand oriented water use policy.

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