Lukić, D., Radosavljevi, M., & Anđelković, A. (2025). Management of water demand elasticity potential, *SCIENCE International journal, 4*(4), 01-07.
doi: 10.35120/sciencej040401l UDK: 622.485:005.336.1

MANAGEMENT OF WATER DEMAND ELASTICITY POTENTIAL

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Abstract: Public water supply, as a natural monopoly, implies the provision of sufficient quantities of drinking water, as well as the drainage and treatment of used water by utility users. Regulatory framework of water supply organizations, availability of resources, management, economic potential, national history and culture; potentially affect the structure and level of water supply prices. Optimization of operating costs of water supply organizations, harmonized supply and demand of water in the context of sustainable development, are inputs in defining the business framework. Based on the conducted independent research, meta-analysis identified and analyzed the examined variables, their Relationship with each other and the moderators. It is necessary to know how supply and demand react to changes in water prices, what are the results and their implications!? Although standard neoclassical economics is based on preferences and a continuous function of water utility, the result of the research on the analysis of indicators of water use, water price and household income, indicates a complex reaction of variables. Price elasticity of demand is a measure of how much the quantity of water demanded changes when its price changes, expressed as a percentage. Principal implements various innovative economic instruments for more efficient management of water resources, promoting water conservation and reducing water consumption, during the implementation of various economic activities. The application of smart systems for measuring water use is recommended, which are based on the development of digital architecture, which creates the prerequisites for determining the direct causality of demand elasticity and pricing policy on the one hand, in relation to total revenue, covering capital investments, operating costs, and providing missing resources and degraded environmental values.

Keywords: *Water supply, pricing policies, elasticity of demand, water use efficiency.*
Field: Social Sciences

1. INTRODUCTION

As a natural resource of general interest, water is essential for basic human needs, and one of the most important factors in economic growth and environmental management. As such, it enjoys special protection from the state.

Public water supply, as a natural monopoly, means the performance of business activities of providing enough drinking water, as well as draining and purifying used water of utility users.

Main causes of barriers to entry are the key resource is owned by one organization, the principal grants a concession – the exclusive right to produce a good or provide a service, and the cost of production makes one producer more efficient compared to many producers. (Mankiw GN. Taylor MP, 2006)

To understand the use of water in the household, in most national regulatory allocation frameworks, are included: (Reynaud, 2015)

The needs of the household and the population as the most priority for the use of,

Most large-scale water use models predict significant changes in household water use over the next 50 years.

Water is an essential good, there is no substitute for most indoor water uses (drinking, personal hygiene, cleaning...).

The elasticity of water demand in relation to price largely depends on the type of market and the water price policy in each country.

By analysing the parameters of the variables (Lopez MG. Montano B. Melgarejo J, 2020) use, use, water price and household income; identifies the complex reaction of use, income and prices; This leads to savings and a lower margin of reaction to the increase in the price of water. This is especially true in conditions when the problem of water supply is (Radosavljević Ž. Andjelković Maja. Radosavljević M, 2021): “becoming more complicated, because it shows that there is already a water supply crisis in large urban areas, which are increasingly becoming overpopulated and consuming more water compared to the previous period, but also due to the decreasing amount of healthy and drinking water, due to pollution at the global level.”.

The aim of this paper is to review water management policies and practices, which ensure the optimal relationship between water prices and changes in the level of water demand, analysis of results

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and their implications.

Principal implements various innovative economic instruments, optimizing harmonized supply, demand and operating costs, for the efficient management of water resources, and promotes water conservation during the implementation of various economic activities.

2. MATERIAL AND METHODS

Demand Management Strategy (DMS) is a systematic approach that organizations use to understand, predict, influence, and meet users' water needs. The goal is to achieve a balance between supply and demand, optimize resources and minimize waste.

The water price model starts from simultaneous elements (Beecher JA, 1994): recognizing public functionality in cost allocation (economies of scale), calibrating the minimum bill according to property valuation (capacity value), providing compensation for necessary household use (public health), designing cost-based pricing for variable water use (resource management) and the prohibition of exclusions and the application of restrictions on water use (water safety).

An empirical study identifies the presumption of the development of water demand over time, taking into account the variants: Assumptions of GDP levels, Demographic assumptions, Water-use efficiency (Javid M, 2024) (WUE) and defined the technology gap in practice to optimize use by 2050, and the price of water to raise financial stability.

The demand for water by households strongly depends on dimensions that include climate, behaviour of water users, efficiency of the technology used during use, incentives and awareness of users when using water. The use of water in the household is viewed through the price of water, household income, demographic indicators, and in modern business conditions, the study uses the WUE indicator as an important determinant of water use.(Javid M, 2024)

Price elasticity of demand is a measure of how much the quantity of water demanded changes when its price changes, expressed as a percentage. The assessment of relevant variables was carried out on the basis of a comprehensive review of the literature, independently conducted research: in terms of price elasticity of demand, in the context of income elasticity of demand, on universal equality and efficiency for determining the price of water; on cost-effective and non-cost-effective approaches to water conservation and assessment of the impact of the increase in water prices on the efficient use of water in households; Regarding the impact of society's policy for saving water in the use of cities in cities; Water pricing policies as a tool to promote efficiency in the management of water resources; on the economics of water scarcity and institutional solutions; 64 econometric studies on pricing policies, elasticity of demand, information and education campaigns in the United States; on cost recovery and elasticity of demand through water prices of water service operators of the 28 EU countries; and consideration of socially acceptable prices of 8 cities in Serbia; Primary data was collected, and using meta-analysis, the examined variables, their mutual and relationship to moderator variables were identified and analyzed (Samuelson PA. Nordhaus VD, 2005) in terms of price elasticity of demand; (Mankiv GN. Taylor MP, 2006) in context of income elasticity of demand; (Becher JA, 2020) on universal equity and efficiency in water pricing; (Javid M, 2024) on price and non-price approaches to water conservation and assessing the impact of water price increases on efficient household water use; (Zhao Y. Min L, 2020) regarding the impact of society's water conservation policies in cities; (Lopez MG. Montano B. Melgarejo J, 2020) regarding water pricing policies as a tool for encouraging efficiency in water resources management; (De Waat D. Khemani S. Barone A. Borgomeo E, 2023) on the economics of water scarcity and institutional solutions; (Maas A. Puri R. Goemans C, 2024) within 64 econometric studies on pricing policies, demand elasticity, information and educational campaigns in the USA; (European Environment Agency, 2017) on cost recovery and demand elasticity through water prices of water service operators in 28 EU countries; and (Лукић Д, 2014) examining the socially acceptable price of 8 cities in Serbia; primary data was collected, and using meta-analysis, the investigated variables, their mutual relationship and their relationship to moderator variables were identified and analyzed.

Smart Water Metering (SWM) technology is a milestone in the field of water management, as the provision of accurate, real-time water use data analyses water usage trends and demonstrates the potential benefits of water savings, with a focus on sustainability and environmental protection. It is necessary to know how supply and demand react to changes in water prices, what the results are and their implications!

3. RESULTS

The use of water in the household does not depend on the price of other goods consumed by the user, for at least three reasons: there is no substitution for the water used in the household, household habits can be considered constant, and it is unlikely that the complementary goods that use water in the household (machinery, washing, sanitation...) will change in the short term.

The equation of water use in the household can be represented as follows:

$$W_t^d = \alpha_{0+}\alpha_1 p_{t+}\alpha_2 \hat{y_t}+\alpha_3 pop_t+\varepsilon_t \quad \ldots\ldots\ldots\ldots (1)$$

In the above equation, it denotes the use of water in the household, - the price of water, - income, and - the population. $W_t^d p_t y_t pop_t$

Some studies have used the WUE indicator as an important determinant of water use, in terms of responsible use, minimization of waste and reduction of the level of water use; which depend on the behaviour of the user and the technological efficiency of the apparatus (machines, low-pressure taps, showers...). Thus, WUE was introduced as a supplementary explanatory variable of Equation (1), and thus obtained the expression:

$$W_t^d = \beta_{0+}\beta_1 p_{t+}\beta_2 y_t+\beta_3 pop_t + \beta_4 wue_t+ \varepsilon_t \quad \ldots\ldots\ldots\ldots (2)$$

Long-term integrated water management involved instruments for setting water prices (e.g., tariffs) and measures not directly related to prices (e.g., water-saving devices, education and awareness-raising campaigns) for more efficient water use.

On the offer side (Lopez MG. Montano B. Melgarejo J, 2020), the increase in prices led to an increase in revenues, creating the prerequisites for the sustainability of new projects, incentives to avoid water losses and enabling improved management through optimal maintenance of the water supply system.

Table 1. Price elasticity of urban water demand in some countries

Serial number	Country	Region	Method	Elasticity of demand for water	Notes	Sources
1.	Spain	North-west	Regression (OLS)	-0.14 to -0.17	1993-1999	(Martinez-Espineira, 2000)
2.			Marginal price	-0,34	Beyond a minimum	
3.				-0,20	Consumption in summer	
4.	France	Gironde	Regression (OLS)	-0,17	1975	Point (1993) in (Nauges, 1999)
5.		Country	Regression (OLS)	-0,10 to -0,20*	1975-1980-1985	(Boistard 1993)
6.				-0,25 to -0,35**	1990	
7.		Country	Regression (OLS)	-0,12	1989	(Pouquet and Ragot, 1997)
8.				-0,32* to -0,31**	1995	
9.		Yerres Basin	Regression (IV)	-0,31	1995	(Le Coz, 1998)
10.		Gironde	Regression (IV)	-0,08	1990 to 1994	(Nauges and all, 1998)
11.		Moselle	Regression (IV)	-0,22	1989-1993	(Azomahou, 2000)
12.			Regression (Panel)	-0,23	1989-1993	
13.	Greece	Athens	Chronological regression series (macro elasticity)	-0,4 small consumers	Consumption Band <15m^3	(Ghini, 2000)
14.				-0,8 large consumers	>60m^3	
15.	Tunisia	Country	Regression	Lower block: -0.06 to -0.15 (Country: -0,08)	Consumption Band <70m^3	(Matoussi and Baranzini, 1998)
16.				Higher block: -0.28 to -0.91 (Country: -0,58)		
17.	Cyprus	Country	Water Demand Model	-0,79 (for the lowest 10% of incomes)		(Haispryrou at all. 2001)
18.				-0,39 (for the highest 10% of incomes)		
19.	Germany	Country	Regression (OLS)	-0,229		European Environment Agency 2017
20.	Italy	Country	Regression (OLS)	-0,47		European Environment Agency 2017
21.	Europe	Country	Regression (OLS)	-0,40		European Environment Agency 2017
22.	USA	Country	Regression (OLS)	-0,41		European Environment Agency 2017
23.	Australia	Country	Regression (OLS)	-0,15 to -0,39		European Environment Agency 2017
24.	Czech Republic	Country	GLSivlag	-0,18 to -0,28		(Reynard, 2015)
25.	Notes: *in the short term (2 to 3 years), **in the long term (5 to 10 years) OLS= Ordinary Least Squares; IV= Instrumental variables					

Sources: http://planbleu.org.en
https://www.eea.europa.eu/publications/water-management-in-europe-price/file#page=7.11

The previous table illustrates the results of the research, which indicate the present range of elasticity of water demand in urban areas of different countries, which is negative and statistically significant. At the same time, two factors had a dominant impact on price elasticity, namely the amount of water (large users are more reactive to price changes than small users) and the level of income User. Water demand became more elastic as volumetric water use was identified, defined by innovative tariff structures and price increases.

The range of income elasticity of the beneficiaries indicated the breadth of the range, and the beneficiaries were willing to reduce their water consumption when the costs began to make up a significant part of the household income, as illustrated by the following table:

Table 2. Income elasticity of water users in some countries

Serial Number	Income elasticity	Country	Value %	Notes
1.	Very low	France, Croatia, Germany, Greece, Austria, Spain	0,00-0,25	A significant impact of changes in household income on water usage per capita is not expected.
2.	Higher	Bulgaria, Estonia, Cyprus, Lithuania, Latvia, Portugal, Slovakia	>0,50	Estimating the trend of water usage is very difficult due to opposing effects: the expected increase in income and the rise in the price of drinking water.
3.	Based on accessibility threshold	Countries in transition	0,5 – 1,2	Serbia, cities: Kraljevo, Loznica, Pančevo, Smederevo, Sombor, Sremska Mitrovica, and Vršac.

Sources: (European Environment Agency, 2017)
(Author's research, 2014)

A real concern, about the accessibility of the service for groups of households with the lowest incomes, in practice pointed to alternative social support instruments in the form of subsidies to water supply operators and infrastructure owners, exemptions of activities with limited impact on the water system, subsidies with the aim of social equality, and environmental improvement goals.

It was necessary for water pricing systems to be designed to consider the specific conditions and characteristics of areas and households, when applying the accessibility threshold.

Information and education campaigns, which are not directly related to prices, provided users with general information, and when compared, they were relatively consistent in the estimated response between 2-8% reduction in average water use. (Maas A. Puri R. Goemans C, 2024)

Defining an effective mix of instruments had to be considered in the context of the specific characteristics of each country, in terms of availability and challenges related to water demand. For several years now, the Republic of Serbia has been facing a challenge regarding water supply, which is why special attention must be paid to the management of water resources. Given that water is a vital necessity, "it is necessary to introduce priorities in water investment.... Which is the problem of the national government, because it is evident that "the state of the water systems is bad. This is also stated in the EU Drinking Water Directive; (Radosavljević D. Andjelković M. Radosavljević M, 2018): "the overall state of water supply systems, which is said to be characterized by the poor condition of infrastructure as a result of equally poor financial conditions of public utility companies, insufficient funding from local self-government units, state budgets and other sources. "

4. CONCLUSION AND DISCUSSIONS

The water supply paradigm is since water is a natural resource of general social interest, which, as a natural monopoly, brings public and private benefits.

Urbanization, socio-economic development, changing patterns of water use and climate change are the main drivers of increased water use. At the same time, there is an inefficient use in the context of rapidly increasing levels of water demand.

4.1. CONCLUSION

The principal implements various innovative economic instruments for more efficient management of water resources, whereby the summary of the findings should be viewed through:

1) The fact that water is a normal good, characterized by levels of water use in the household, which increase with the increase in the level of household income.

2) Smart infrastructure (technologically advanced pipelines, designed valves in the network, leak locators, digital meters and two-way communication in real time) with proactive management, is the backbone of modern water supply management.

3) The WUE indicator is an important determinant of the responsible use of water and the technological efficiency of the appliances used.

4) Water users, traditionally encounter one of the four price structures and are poorly informed about the price structure.

5) Price elasticity of demand is a measure of how much the quantity of water demanded changes when its price changes, expressed as a percentage. The analysed studies indicate a typical price elasticity of demand in the range of -0.10 to -0.40, in most countries.

6) The income elasticity of demand shows the extent to which the amount of water demanded

responds to changes in household income. The fact is that households with relatively low incomes are the most sensitive to changes in water prices, and the income elasticity of water demand is different, given the stability of income per capita, expected income growth, i.e. the expected trend of water prices in countries.

7) The problem of tariff affordability has emerged in countries in transition, following the abolition of price controls, the reduction of public sector subsidies and the overcoming of the gap between the payment of the fee and the cost of water supply.

8) Subsidies and exemptions from water charges, by creating market distortion mechanisms in the implementation of pricing policies, prevent the efficient use and allocation of resources.

9) Public awareness campaigns are considered an effective means of reducing water use. In times of acute water scarcity, they are considered effective in the short term and have little or no demand impact in the long term unless accompanied by other measures.

4.2. DISCUSSIONS

Water is a homogeneous good, which in real conditions of use in the household is a complex good. Structurally, it consists of (Reynaud, 2015) direct use of a small amount of drinking water, and as a supplement to other household activities for washing, cooking, hygiene.

The use of domestic water implies the assumption that there is no substitution for the water used in the household, household habits can be considered constant, and it is evident that the complementary goods that use domestic water (machinery, appliances and sanitary facilities) are unlikely to change in the short term.

The analysis of indicators of water use, price and household income indicate a complex reaction of the identified and analysed variables. Primarily, the question arises of the incentives of the existing pricing system and their implications for more efficient use of water.

The structure of the price of water implies a different econometric approach, whereby the following are recognized: lump sum – which implies the possibility of charging for used water without installing a water meter, without determining a marginal cost; unique – implies a constant volumetric limit price; seasonal – due to the influence of geographical, climatic differences of the territory, associated with high temperatures and the arrival of tourists; and layered nonlinear structure – based on the use of m3, varies within certain ranges of use, has the forms of an increasing and decreasing structure.

The management systems of water supply organizations vary significantly, depending on the specifics of the country, national history, regulatory framework, culture, and availability of water resources. (Dige G. Strosser P. De Paoli G. Anzaldua G, 2013)

Demand management strategies are a systematic approach used by organizations to understand, predict, influence, and meet users' water needs. The goal is to achieve a balance between supply and demand, and to optimize resources and minimize waste.

In a real-world environment, it is not possible to separate the different types of demand, so the estimated elasticity is based on the aggregate household demand for water. The range of elasticity of the demand of groups of users for water was registered for the first time in individual users -0.20 to -0.40, with a price increase of 10% reducing water demand by 2-4%; and in commercial and commercial -0.50 to -0.80. (Beecher JA, 1994)

The elasticity of demand is typically non-elastic for most EU countries, the use of water in the Households are falling by less than 1% for every 1% price increase, according to a report by the Joint Research Centre - Institute for Environment and Sustainability "... A 10% price increase is expected to reduce household water use by 1-5%" – suggesting that the price of water plays a role in the process of signalling water scarcity or household water costs. (Reynaud, 2015)

In Italy and France, water demand is correlated with household size – a factor of 1.6 and 0.8 respectively. A very similar effect is identified in situations where there is a common water meter for several apartments in an apartment building.

The elasticity of the price of demand measures the sensitivity of water use to changes in household income, provided that all other conditions are equal. Households with relatively lower incomes are the most sensitive to price changes, because they allocate a larger part of monthly household expenditures. At the other end of the price adjustment spectrum, we identify households with irrigation, watering, swimming pool systems... They don't respond to price increases with the same approach.

When considering the problem of the accessibility threshold, the key question is whether the user could pay and whether he is willing to pay for the water used. The threshold for the accessibility of water use is defined differently (Лукић Д, 2014) by international and bilateral financial organizations (OECD=3-5%, EU=3-4%, US EPA=2.5% и IFI=4%) of household income. The Socio-Economic Study of Water Supply in Serbia, conducted in 2005 and 2008, analysed clusters of all variables (average number of

household members, average income per household member, daily water consumption per capita, and accessibility threshold according to the standards of organizations) of household budget use to determine the part of household income on water use in the cities of Kraljevo. Loznica, Pančevo, Šabac, Smederevo, Sombor, Sremska Mitrovica and Vršac.

Subsidies and exemptions from water charges, as alternative social support instruments, can play an important social and political role in times of crisis.

Information and educational campaigns are not directly related to prices, they include billboards, emails, classes and social networks. (Maas A. Puri R. Goemans C, 2024)

Most of the reference studies on the price elasticity of water demand date back ten years or more but are still in use. There is a need to develop new case studies with primary data, which would provide relevant evidence, and explain contemporary socio-economic, managerial and technological changes.

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