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Water demand management strategies for water-scarce cities: The case of Spain

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ABSTRACT

This paper provides an overview of pricing and non-pricing measures to reduce domestic water consumption at the household levels in five urban areas in Spain. Analyses are based on questionnaires sent to water utilities that provide water services in the metropolitan areas of Barcelona and Seville, the cities of Malaga and Saragossa and the region of Madrid. Our main contribution is that, compared to studies that are based on estimates of the water demand function, we asked directly the managers of the utilities on the effectiveness of the measures implemented. We found that all areas studied have implemented pricing and non-pricing measures to encourage the efficient use of water and that reduction in per capita water consumption has been the result of periods of drought, accompanied in certain cases by water restrictions and pricing and non-pricing measures. In all five areas studied, the utilities believe that non-pricing measures have had a greater impact on water consumption decisions compared to pricing measures.

1. Introduction

An important concern in the world is to improve overall management of water resources. One of the main objectives of water management is to provide clean water in the quantity and quality that is required for all uses, manage it sustainably and provide sanitation and wastewater management services for all (UN, 2015). In developed countries, even though access to water is almost universal (WHO and UNICEF, 2017), there are chief concerns such as improving further water management, including water quality, infrastructure replacement and upgrade, impacts of climate change, and interest for water at the highest political levels (OECD, 2015, 2018).

The interest to improve water management and achieve more efficient water use in the several sectors has increased in geographical areas where water stress is becoming more frequent (Luo, Young, & Reig, 2015). For the domestic sector, pricing and non-pricing instruments have been used in different ways to reduce water consumption per capita, mainly in developed countries (García-Rubio, Ruiz-Villaverde, & González-Gómez, 2015; Garcia-Valiñas, Martínez-Espiñeira, & To, 2015; Sahin, Bertone, & Beal, 2017).

Price increases are generally controversial because of the impacts they can have on the population from socioeconomic viewpoints (Arbués, Garcıa-Valiñas, & Martınez-Espiñeira, 2003). They are also the least preferred action by any sector of society. Policymakers and utility managers thus have to perform a delicate balancing act every time they have to decide if they should enforce pricing or non-pricing mechanisms aiming at reducing water consumption and to what extent. It is known that, while water tariffs are considered as the most direct way to promote multiple objectives such as net revenue, stability and efficiency, they should also consider that clean water has to be provided at affordable prices to all sectors of society (Pinto & Marques, 2015).

Reseach on tariff-based demand indicates that water pricing measures can be effective to promote conservation measures, but only in specific cases. There are instances when increase in prices would have a similar impact in terms of water conservation than extending tariff blocks (Sahin et al., 2017). In a study on 13 water demand management policies in four European cities (Stavenhagen, Buurman, & Tortajada, 2018), the authors found out that investment in renovation and maintenance of networks are the most important measures to conserve water, followed by regulations, individual meters and public campaigns promoting the use of water-saving technologies and water-conservation practices. None of the cities studied showed that prices had been the most important trigger for water conservation. This is consistent with other studies such as Schleich and Hillenbrand (2009) who analysed

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econometrically the impact of a series of economic, social and environmental variables for 600 water supply areas in Germany. It is also the case for other cities (Lu, Deller, & Hviid, 2017) and can be explained because water and sanitation expenses tend to represent a very small percentage of household income.

Domestic water consumption also depends on numerous other variables such as household size, demography and climate (Corbella & Sauri, 2009) as well as behavioural and psychological variables (Fielding, Russell, Spinks, & Mankad, 2012). In fact, several utilities are trying to incorporate behavioural nudges in their strategies (Smith & Visser, 2014). The messages delivered by policymakers and utilities on the desirability of the population adopting conservation measures irrespective of the climatic conditions, has also been found to be equally important. This is because a consistent message contributes to a sound culture of water conservation (Fielding et al., 2012).

In the case of Spain, a change of paradigm in the management of water supply services for domestic use started at the end of the 90s and early 2000s. Both a severe drought in the mid-90 s and the Water Framework Directive of 2000 (European Commission, 2000) triggered policy, management, administrative and infrastructure measures that resulted in a progressive and continuous reduction of water consumption per capita. On average, this has reduced from 168 litres in 2000 to 132 litres in 2014 (INE, 2015).

In order to understand the reasons behind this reduction on water consumption in the several cities in Spain, numerous factors that have influenced domestic water use have been studied. However, this analysis has not been comprehensive enough because it has emphasized pricing measures in order to try to undertand the impact of non-pricing measures. Arbués, Barberan, and Villanua (2004), Arbués & Villanua (2006) and Arbués, Villanúa, & Barberán (2010) have focused their research on the city of Zaragoza. Findings include that residential users are more responsive to a lagged average price specification, that price is a moderately effective tool in reducing residential water demand and that small households are more sensitive to price changes. Martinez-Espiñeira (2002, 2003a, 2003b), Martínez-Espiñeira and Nauges (2004) studied cities in the north of Spain and the cities of Seville and Granada in the south, and concluded that climate-related variables influence more monthly use of water in water-scarce areas mre than in humid areas, that elasticities are inversely correlated to the size of free allowances covered by minimum charges, that there is a nondiscretionary amount of water that is not sensitive to price changes and that there is an additional quantity devoted to discretionary uses that does respond to price variations. Hoyos and Artabe (2017) have studied the influence of regional climate variability on the elasticity of price for residential water demand in Spain as a whole, and Deyà-Tortella, Garcia, Nilsson, and Tirado (2017) have analysed water prices and residential water consumption for three different housing typologies with contrasting household characteristics.

More recently, some studies have started focusing on non-pricing measures. Martínez-Espiñeira and García-Valiñas (2013) have studied the aspects that determine the adoption of water-saving technologies and water conservation habits in households in Spain. Their findings indicate that educational campaigns have a strong positive effect on the decision of the households to purchase water-saving technologies and adopting water conservation habits. But Martínez-Espiñeira and Nauges (2004) found out that conservation habits and use of water-efficient appliances are more related to water and energy consumption rather than only water.

In this paper, our objective is to do a comprehensive analysis of the pricing and non-pricing mechanisms that encourage water savings in households in urban areas in Spain. Specificially, we study a series of measures that have been implemented in five large areas in Spain to reduce domestic water consumption per capita between 2002 and 2016. Our first hypothesis is, as Martínez-Espiñeira and Nauges (2004) discuss, that non-pricing measures are more effective for water saving purposes than pricing measures. We also aim at understanding which non-pricing measures have been most effective to achieve the lowest water consumption per capita. In the case of our study, contrary to others, a water demand function is not estimated. We have asked directly the utility managers to explain how useful the several measures of the water utilities have been. We conclude that non-pricing measures are more effective than pricing measures to reduce water consumption per capita. However, there is no consensus on which one is the most effective non-pricing measure among the several that were used. In each case, it depends on the specific context. To our knowledge, this is the first analysis that considers holistically the impact of all measures used to achieve water savings for residential use in Spain.

The importance of this paper is twofold. One is the study of efficient urban water management practices in various cities in Spain in a holistic manner including all measures, pricing and non-pricing, to achieve water savings in households. The second is that our findings can be used by other cities, metropolitan areas or regions that need to reduce domestic consumption at present, that are planning to do it in the future, or that may have to take the decision to implement water efficiency measures in the future when necessary. In all cases, they will be able to use the experiences and lessons learnt from Spain.

After this Introduction, the rest of the paper is structured as follows. Section 2 discusses urban water management practices in Spain, followed by Section 3 where the methodology is presented and by section 4 with the results. Section 5 discusses the findings. We finalise the paper with a section that includes conclusions and recommendations

2. Urban water management in Spain

Policy decisions and strategies aiming at water consumption, as important as they are, have not been adopted uniformly across Spain. The authorities that can influence domestic water consumption are not centralized; in fact they are very decentralized, which means that the degree of implementation of the various measures differs greatly between service areas. In Spain, urban water supply, sanitation and wastewater treatment are managed at the municipal level (articles 25 and 26 of Local Government Regulatory Law 7/1985, of 2 April). There are 8125 municipalities and 8117 local government authorities with decision-making power concerning water services within their municipal boundaries. Consequently, one of the primary characteristics in the management of urban water services in Spain is the atomization of the industry and, therefore, of the measures aimed at reducing water consumption.

According to the relevant Spanish regulations, drinking water, sanitation and wastewater services can be managed in a number of ways: it can be done by the town council itself, by a local or regional organization, or by a company whose capital stock is fully owned by the town council (a municipal company). The choice is made directly by the local government, without any type of control or intervention from upper levels of the government—either regional or national —or any other autonomous organization.

Another feature of the Spanish model for the management of urban water services is that private-sector participation in the industry is concentrated in just a few predominant companies. Aguas de Barcelona (AGBAR) and Aqualia operate in 67% of the municipalities that have privatized the management of urban water services (González-Gómez, García-Rubio, & González-Martínez, 2014). Other companies in the sector are Acciona, Valoriza, Gestagua, Aguas de Valencia, FACSA, Agua y Gestión, PRODAISA, Hidrogestión and Espina & Delfín. In terms of population, AGBAR and Aqualia control 75% of the private sector in this industry—an oligopoly. Furthermore, each of these two companies is part of a larger business group: AGBAR is a subsidiary of Suez Environnement, while Aqualia belongs to FCC (Fomento de Construcciones y Contratas), giving them even greater market strength.

Also noteworthy is the *regional specialization of the industry*. Over time, private companies have strengthened their positions in geographical areas by expanding their influence to nearby population

centres. Thus, although Aguas de Barcelona is all across Spain, it maintains a dominance in Catalonia, and has a major presence in Alicante, Murcia, Granada and Ciudad Real, among others. Aqualia has a greater presence in the municipalities along the Andalusian coast, in Toledo and Badajoz. Others with a notable local presence are Aguas de Valencia in the province of Valencia, FACSA in the province of Castellon, PRODAISA in Girona and Espina & Delfín in Galicia.

The degree of competition of the water industry could affect management decisions of the private utilities. Depending on how competitive the environment is, private utilities might have different incentives to invest in actions aimed at reducing per capita water consumption. In this regard, private sector involvement in the provision of water supply has become very controversial. Several NGOs, community organizations, unions, foundations and political parties demand the re-municipalization of water supply services in those cities where management of water has been privatized. These groups also oppose privatization of services in more cities. The "Social Pact for Water" (Iniciativa Agua, 2015) endorsed by several organizations, states that any model of public management looks after the interests of the population better than the private sector within a framework for sustainable management of water resources.

Given the natural monopoly of urban water services, the participation of private utilities in the water industry and the high degree of concentration of private sector utilities, regulation of the sector is key. Yet, another characteristic of the Spanish model of management of urban water services is the *lack of a regulatory body for the industry*. In this regard, the Spanish privatizing model is closer to the French model and different from the British. In United Kingdom a national regulatory body was set up in 1989, the present-day OFWAT, the UK's Water Services Regulation Authority.

The analysis above indicates that decisions on pricing and non-pricing measures are very decentralized in Spain. As a consequence, private sector utilities have wide-ranging autonomy to take decisions locally that affect water users in diferent ways. It is thus expected that strategies and decisions are different among the several water utilities.

3. Methodology

3.1. Scope of the study

Assessing the measures adopted in the more than 8000 municipalities in Spain would be beyond the scope of this paper. Instead, we studied a small number of areas. These include: the metropolitan areas of Barcelona and Seville, the cities of Malaga and Saragossa, and the region of Madrid. Barcelona, Malaga and Saragossa were selected based on an OECD report (2016), where they are mentioned as some of the best examples of water demand management. Seville and Madrid were selected because they have registered decreasing per capita water consumption in recent years. Each of the five areas has more than 500,000 inhabitants, and has implemented various measures and strategies to encourage the efficient and sustainable use of water in the domestic sector. Combined, all utilities considered in the study provide water supply services to 25% of the population in Spain.

3.2. Information sources

The study covers the 2002–2016 period and is based on information available on web pages and reports of governments and utilities; government reports of the provinces and autonomous regions; and municipal regulations aimed at more efficient use of water resources.

Additionally, questionnaires were sent to the heads of the following water utilities:

- EMASA: Water management in the city of Malaga is carried out by Empresa Municipal Aguas de Málaga, S.A. (EMASA). The capital stock of the company is fully owned by the Malaga City Council. The company provides complete water cycle management services to a population of about 570,000.
- EMASESA: The Metropolitan Water Supply and Sanitation Corporation for Seville (EMASESA) provides complete water services to approximately 1.1 million inhabitants in 12 municipalities—Seville and 11 towns and cities within the metropolitan area. EMASESA is a public utility. The city of Seville owns 69% of the shares of the company.
- Aguas de Barcelona: the metropolitan company responsible for managing the complete water cycle, provides water services in the city of Barcelona and its metropolitan area. Its service area extends to 36 towns and cities, comprising almost 3 million people. It provides water supply and water treatment services to 23 municipalities, and wastewater treatment to 36 municipalities. The company has public–private capital. SGAB (Sociedad General de Aguas de Barcelona) holds 70%, while AMB (Metropolitan Area of Barcelona) and Criteria hold 15% each. Criteria is an investment holding company of Fundacion Bancaria La Caixa.
- Canal de Isabel II Gestión: The Canal de Isabel II company oversees the complete water cycle management of 179 municipalities in the Region of Madrid. Through its distribution network of 17,366 km, the company provides water services to 6.21 million people. Canal de Isabel II is a public corporation. In addition to its activities in the Region of Madrid, the company manages the water service in other cities of Spain, Colombia, Ecuador and Brazil. Shareholding is divided as follows: Region of Madrid: 82.4%; Madrid City Council: 10.0%; other local councils in the Region of Madrid: 7.6%.
- Municipal Water Office of the city of Saragossa: The complete water cycle management in the city of Saragossa is under the city council, through its Municipal Office of Water. It is one of the few cities in Spain where these services are managed by the city council, as it is a more standard practice to outsource this service to one of the utilities set out in the Spanish regulations. The Municipal Office of Water provides service to just over 700,000 inhabitants.

One of the authors of the study administered the questionnaire. Questionnaires comprised eight questions. These included the volume of cubic metres of water consumed per person per day for residential use; how the company calculates the consumption of water per person per day; pricing and non-pricing measures the company considers that have been effective to reduce consumption of water during the last decade (rated from least to most important); initiatives on which the company has invested the most to reduce water consumption during the last decade; if any public institution (and which one) has supported the companies on the implementation of the decisions taken; and if the measures taken to reduce domestic water consumption were part of individual initiatives or initiatives that were part of an integrated programme to reduce water consumption. Finally, an open question for additional comments.

3.3. Data treatment

The information presented includes the consumption of water per capita in each household in the area studied, the evolution of the tariffs in terms of system and structure, and the non-pricing measures that have been implemented to reduce per capital water consumption. It refers to water that has been billed and not that is in the distribution networks.

The evolution of water consumption per capita covers residential use only. Any other use such as commercial or industrial was not considered.

The tariffs were calculated considering the price of a cubic metre of water for the hypothetical consumption of 15 m^3/month per household. As discussed in González-Gómez and García-Rubio (2018), previous studies on water tariffs have considered different levels of consumption per month per household. In our case, we selected 15 m^3/month

because this is the volume that has been used as a reference in other studies that have focused on Spain (Martínez-Espiñeira, García-Valiñas, & González-Gómez, 2012; García-Valiñas, González-Gómez, & Picazo-Tadeo, 2013; Martínez-Espiñeira, García-Valiñas, & González-Gómez, 2009).

For the progressivity of the tariff, the indicator is based on a recent publication by Suárez-Varela, Martínez-Espiñeira, and González-Gómez (2015) and Suárez-Varela and Martínez-Espiñeira (2018). This is calculated as follows:

$$\text{PROG}= \frac{\sum_{w=5}^{50}\left(\frac{\text{bill}_w}{w}-\frac{\text{bill}_{w-1}}{w-1}\right)}{\frac{\text{bill}_{25}}{25}};\ w=\{3\,\text{m}^3,\ 5\,\text{m}^3,\ 10\,\text{m}^3,\ 15\,\text{m}^3,\ 20\,\text{m}^3,\ 25\,\text{m}^3,\ 50\,\text{m}^3\}$$

where w is the consumption of water in cubic metres, and *bill* is the water bill for that consumption.

The analysis of the pricing measures is complemented by an analysis of the non-pricing measures. This is based on the information provided by the utilities. The information in the questionnaires allowed us to understand the effectiveness of the several measures to reduce the levels of consumption.

4. Results

4.1. Consumption per capita

The information in Table 1 confirms the reduction in per capita water consumption for domestic use for all the areas studied. In 2002, the lowest consumption was in Barcelona with 127 m^3 per person and a maximum of 172.3 m^3 in Madrid. In 2016, the highest consumption was in Madrid with 128.5 m^3 and the lowest was in Saragossa with 96 m^3. According to the information provided by the utilities, there is a continuous trend in the reduction of water consumption per capita for all areas studied. This information corresponds with that provided by the National Institute of Statistics (INE, 2016).

4.2. Decision-making by water utilities

One of the objectives of the questionnaire was to try to understand the rationale for the measures taken by the water utilities to reduce water consumption.

In the first place, it was clear that water conservation is an objective for all the utilities studied. In all cases, the managers of the companies responded that their integrated water management action plans include measures to reduce water conservation per capita.

In a manner consistent with the degree of decentralization of decision-making in the urban areas, the interviewees agreed that in order to implement the water saving measures, they had the support of the municipality and, to a lesser extent, of the regional government. They seldom had the support of the national government, and only for specific projects, they had funding of the European Union.

To achieve reduction in the consumption of water, the utilities said that they had implemented both pricing and non-pricing measures. In all cases, those responsible for the utilities emphasized that non-pricing measures have had a greater impact in the reduction of water consumption per capita compared to the pricing measures. Likewise, they agreed that non-pricing measures take more effort to implement.

Table 1
Water consumption for residential use (cubic metre) (2002 and 2016).

	Year	Barcelona	Saragossa	Málaga	Madrid	Sevilla
Consumpion per capita	2002	127.9	130.4	129.0	172.3	139.0
	2016	102.2	96.0	111.0	128.5	113.0

Table 2
Water tariffs for residential uses* (2002–2016).

	Year	Barcelona	Saragossa	Malaga	Madrid	Seville
Price of m^3 of water (€/m^3)	2002	1.00	0.75	0.78	0.95	1.00
	2016	2.14	1.18	1.22	1.44	1.77
Weight of the fix component in the price of m^3 of water (in percentage)	2002	n.a.	33.33	19.16	29.33	27.45
	2016	26.06	22.18	19.49	36.63	23.08
Progressivity indicator in the variable part of the tariff	2002	0.72	0.55	1.06	0.67	0.58
	2016	0.99	0.98	0.93	0.89	0.84

* Calculations are based on a hypothetical consumption of 15 m^3 of water per month per household.

4.3. Pricing measures

In the five areas studied, dual tariffs are applied, with fixed and variable fees. This practice is widespread in practically all Spanish cities (García-Rubio et al., 2015). In Madrid, Barcelona and Saragossa, tariffs are applied based on consumption at the household level. Specifically in the cases of Malaga and Seville, recently, tariffs have been applied based on water consumption per capita *within the household* (García-Rubio et al., 2015). This system is more equitable for the consumer. It avoides penalizing large families who, even with a low per capita consumption, would be charged in higher blocks within the tariffs structure and pay more per cubic metre of water. This system considers more accurately the consumption per capita. To our knowledge, there are no other cities anywhere in the world that apply per capita rates within households.

Between 2002 and 2016, water prices have increased in the five areas studied. From an interval of 0.75 to 1.00 Euros/m^3 of water in 2002 to an interval of 1.22 to 2.15 Euro/m^3 of water in 2016 (Table 2). On average, the weight of the fixed component of the tariff went from 27.31% in 2002 to 25.35% in 2016. Over time, the fixed component of the tariff does follow a variable pattern. A larger fixed component of the bill ensures revenue to the company to cover the costs of the service. With the exception of Malaga, in the rest of the areas, a greater progressivity was observed in the variable part of the tariffs between 2002 and 2016.

Considering a hypothetical consumption of 15 m^3 of water per household, the weight of the water bill for an average income is between 0.76% in Madrid and Saragossa and 1.49% in Barcelona (Table 3). The data show that, on average, the affordability criterion is met, whereby the weight of the water bill in the family budget must be less than 3% (For affordability criteria, see for example, UNDP, http://www.un.org/waterforlifedecade/human_right_to_water.shtml). In fact, even for consumption levels of 25 m^3 of water per month, except for the case of Barcelona, the weight of the bill in the family budget would remain below 3%.

Managers have introduced additional measures in the tariff system to achieve a more efficient use of water at the household level. These measures include:

Table 3
Weight of the water bill in the household income (in percentage) for different levels of water consumption per month at the household level (2016).

	3 m^3	5 m^3	10 m^3	15 m^3	20 m^3	25 m^3	50 m^3
Barcelona	0.52	0.61	0.96	1.49	2.51	3.71	9.73
Saragossa	0.26	0.30	0.51	0.76	1.18	1.78	4.81
Malaga	0.28	0.34	0.60	0.92	1.30	1.87	5.13
Madrid	0.39	0.45	0.60	0.76	0.99	1.22	3.34
Sevilla	0.40	0.48	0.73	1.11	1.84	2.57	6.24

- Incentives for low water consumption. In Seville and Saragossa there are discounts on the water bill for efficient use of water. One alternative is to define the level below where a discount is applied to the bill; another alternative is to apply the discount taking into account the evolution in time of consumption.
- The application of different tariffs according to the season of year. For example, in Madrid there are winter tariffs and summer tariffs. The higher tariffs in summer are a signal for the user to consume less water in the months of greatest water scarcity.

In the questionnaires, we also asked what are the two measures that have influenced the decisions of the consumers the most: changes in the water tariffs or changes in the progressivity of the tariffs. With the exception of Malaga, in the rest of the areas studied, the increase in the progressivity of the tariffs has had a greater impact on consumers' decisions compared to increases in the tariffs. The answers seem consistent with the evolution of the progressivity indicator shown in Table 2.

4.4. Non-pricing measures

When asked about which non-pricing measures have been most effective in reducing water consumption per capita, the ones that obtained the highest scores in the questionnaires were education and public awareness campaigns aimed at making a more rational use of water, as well as targeted campaigns to promote the use of water-saving technologies (Table 4). At a second level are the measures that have been approved to replace collective meters by individual water meters, as well as the regulations approved at the municipal level to promote a more efficient use of water. Finally, at a third level, were the improvement in the control of illegal conections and the use of devices for leak detection.

It is important to note that the responses of the utilities did not follow a specific pattern. Since different types of measures have been implemented in the various areas studied, the impacts, and their relevance, also differ.

In the case of Aguas de Barcelona, certain non-tariff measures have had a major impact on the decisions of the consumers on the use of water. Most notable have been the campaigns to raise public awareness. According to the company's management team, in relation to the investment made, these have been highly effective. Particularly valuable have been the campaigns to encourage water-saving practices including programmes that aim to educate students of all ages on the value of water.

The company has also made significant efforts to standardize individual water meters, though the effect is expected to be smaller compared to the public-awareness campaigns. The new, highly accurate water meters can detect water leaks in private residences and notify the consumer, enabling prompt repair. They also enable the utility to improve the efficiency of the water network and to react as quickly as possible should interventions be required. As a complementary measure, the company notifies clients by email when higher consumption (compared to water bill records) or leakages are detected. Furthermore, regardless of the water bill records, the client will be notified of what the company considers excessive consumption. In cases of very high consumption, the company will even contact the client by telephone.

Aguas de Barcelona has invested in the design and construction of a distribution network that is organized by sectors. The sectors have monitoring points from which flow data are collected every 10 min throughout the day. This information, which is collected at the Operational Control Centre, can indicate if there are any leaks. It also helps to reduce per capita water consumption because it makes it easier to identify illegal connections.

The Barcelona City Council encourages the responsible use of water through its municipal ordinance on the environment, approved in 2011. The ordinance prohibits practices that result in an excessive use of water, mainly negligence if not repairing leaks immediately, lack of monitoring or maintenance, water theft, sprinklers and watering systems, or any other activity that might result in water spilling out in an uncontrolled manner onto public roads or land.

In the case of Saragossa, water managers mentioned that the replacement of collective water meters with individual meters has been one of the measures with the greatest impact on reducing per capita water consumption. In this regard, Saragossa is believed to be one of the Spanish cities with the highest number of homes with individual metres. There are more than 340,000 water meters—one meter for every two inhabitants. A programme is underway to replace old water meters with electronic ones. The new meters provide additional information about water consumption, such as *when* the water is consumed, which gives an idea of the residents' habits, and at what times they consume more. It also enables the real-time detection of irregularities in consumption, leaks or damages, which register as peaks in the readings. It also helps monitoring illegal connections.

Water managers also believe that campaigns to promote the use of water-saving technologies have had a major impact. However, Barberán and Salvador (2010) mention that public awareness measures should have had a greater impact compared to the implementation of water-saving technologies in homes over the years.

Campaigns to raise public awareness have played an important role in the integrated programme implemented by the city council. In this regard, a decisive factor has been the joint activities between the city of Saragossa and the ECODES Foundation (Fundación Ecología y Desarrollo), which in the mid-1990s started working on public awareness projects aimed at water savings and efficient water use. The Foundation coordinated the "Saragossa, Water Saving City" project in collaboration with the Saragossa City Council and the Regional Council of Aragon werer also positive to encourage water conservation. This programme aimed to encourage consumer demand for water-saving technologies at the household levels, give a boost to the water-saving technology market, and train and inform sector professionals (Fundación Ecología y Desarrollo, 2001). At the end of the project, there was an estimated saving of 1176 million litres of water in a year, with two out of every three households using some form of water-saving technology.

Regarding regulations, in 2010, the Saragossa City Council approved a Municipal Ordinance for Ecoefficiency and Quality in

Table 4
Impact of the several measures used to reduce water consumption per capita for residential uses (Scale 1–5).

	Mean	Standard deviation	Maximum	Minimum
Education and awareness campaigns for a more efficient use of water (showers instead of baths, car washing, etc.)	4,80	0,45	4	5
Campaigns to promote the use of water-saving technologies (water-efficient appliances and fixures, etc.)	4,00	1,00	3	5
Universal installation of individual water meters	3,60	1,67	1	5
Regulations at the municipal level	3,40	1,34	2	5
Control of ilegal consumption	3,00	1,00	2	4
Instalation of leak detection equipment	2,60	0,89	2	4
Laws at the European Union and national levels	1,60	1,34	0	3
Laws at the regional levels within Spain	1,60	1,14	0	3

Complete Water Management, which emphasizes water-saving measures and efficiency in buildings. This includes monitoring water use within the households, which would require installing meters for the washing machine, the dishwasher and the bathroom. The aim is to acquire data for scientific purposes in order to improve the management of water resources. Additional efforts to use water more efficiently included planting drought-tolerant plants in public gardens, and introducing intelligent irrigation systems to minimize water use (Celma, 2011).

In Malaga, one of the measures highlighted by EMASA was the launch of the Water Individual Meter Plan for more accurate metering. The company estimates that there are still around 40,000 homes where water consumption is measured using communal water meters. EMASA estimates that each of these homes is consuming 20% more water than it would be if it were using an individual meter. As replacing a water meter costs around 900 Euros, the company helps with the upgrade. For several years, EMASA has been subsidizing the first 150 Euros of investment as a non-repayable subsidy and financing the rest through a loan that is paid off through small amounts added to successive bills. Recently, the company also acted as guarantor for loans to finance water meter upgrades in residential communities. In recent years, the company has also implemented a measure to replace old meters with electronic ones, moving from a system of traditional mechanical, manually-read meters to meters that enable readings of water consumption to be taken in real time.

Potentially, increasing public awareness is the major factor when it comes to explaining water saving in homes. In the case of Malaga, to a large extent, the degree of public awareness is conditioned by the fact that the city has suffered several droughts over the past two decades, sometimes accompanied by water restrictions, or the threat of restrictions, in households. It is generally accepted that the behaviour of families in this type of situation can undergo long-term changes. Nevertheless, as the company itself acknowledged in the questionnaire, investment in public awareness campaigns is relatively low. Along these lines, in contrast to the other case studies analysed in this report, the companyy does not advocate educational campaigns aimed at students and only on the company's web page there is a section where they provide advice on more efficient and responsible use of water.

In Madrid, Canal de Isabel II mentioned that the most effective measures to reduce water consumption have been awareness campaigns. Their most well-known project is *Canal Educa.* This is a comprehensive environmental education programme that enables Canal de Isabel II Foundation to reach all school children with information on water conservation, sustainability issues, and lately, climate change.

Although to a lesser extent, another measures that have had visible impacts in terms of water conservation have been monitoring of water consumption in households, illegal connections, and the replacement of collective water meters with individual water meters. Furthermore, for the past couple of years, aerial surveillace has been used to oversee green areas and swimming pools in urban areas to detect irregularities in water use. One novel measure in the region of Madrid has been on the developments of commercial activities or residential properties with green areas of 5000 m^2 or more. Such projects are required to recycle water in their watering systems, in addition to adhere to plumbing codes to reduce water consumption.

In Seville, one measure that has had a significant impact both in the city and its conurbations has been the universal installation of individual water meters. To do this, the Plan on Individual Meters in Communities (Plan CINCO) was launched in 1997 by EMASESA, aiming to replace communal water meters with individual ones to encourage water savings at the household levels as well as the responsible use of water. The plan was supported with substantial funding and a series of subsidies were made available to replace water meters. In 2016, the subsidy available for neighbours who changed from a general meter to individual meters was 93.76 Euros per household. The company estimates that this has resulted in a 25% reduction in domestic consumption. Equally useful to promote the rational use of water have been the education and awareness campaigns that have been implemented traditionally by the company within a framework of environmental education and sustainable use of water.

5. Discussion

Utilities stressed in all the cases that the non-pricing measures were more effective than pricing measures to reduce the consumption of water per capita. This result coincides with previous research (Lu et al., 2017; Schleich & Hillenbrand, 2009; Stavenhagen et al., 2018). Particularly indoor water use, which generally covers more essential uses such as food preparation and personal hygiene, and which hardly changes when tariffs increase (Arbués & Villanua, 2006; Olmstead & Stavins, 2009).

This response is not surprising given that the price of water in Spain is low in relative terms in the context of developed countries (GWI, 2017; IWA, 2016; OECD, 2010). As discussed earlier, for a consumption of 15 m^3 of water per month per household, the water bill represents less than 1.5% of the household income. This coincides with data of the Spanish Association of Water Supply and Sanitation (AEAS) and the Spanish Association of Management Organizations of Urban Water Supply (AGA) who, in a recent publication, reported that the water bill represents, on average, 0.9% of the household income in Spain. In addition, the price elasticity of the demand is low, which has been shown both in the Spanish context (Martínez-Espiñeira & Nauges, 2004; Martínez-Espiñeira, 2002; Hoyos & Artabe, 2017) and the international context (Arbués et al., 2003; Worthington & Hoffman, 2008).

Although the tariff system is progressive in blocks, the consumption would have to be extraordinarily high for the water price to have a significant weight in the household income. These high levels of consumption only occur in upper-middle-income families that have single-family homes with gardens and swimming pools where they live most of the time, and second residences where they spend summer. The price elasticity of water demand increases with the level of consumption (Kenney, Goemans, Klein, Lowrey, & Reidy, 2008; Sebri, 2014), while the income elasticity of demand decreases with the level of income (Worthington & Hoffman, 2008). Overall, high-income families are expected to continue enjoying the swimming pool and the views of the garden, but to adopt measures that result in water savings. For example, replace tropical plants in the garden with native plants that require less water, or using cleaning and maintenance techniques that do not require changing the water of the swimming pool frequently.

The water utilities mentioned that additional modifications in the tariff system, such as the summer rate or the discount for an efficient use of water at home, do not have a significant impact on water consumption at the country level. Their experience is that discounts have very little impact on the water bill to significantly modify the behavior of the families.

Overall, it was mentioned that non-pricing measures have been more decisive in reducing per capita water consumption in recent years. Campaigns to raise public awareness about the more rational use of the resource seem to have had tangible results. During droughts, such as those of the mid-1990s and the mid-2000s, and to a lesser extent during the summer months, national and regional public authorities invest in advertising campaigns so that people make a more responsible use of water. But more significant are the permanent campaigns that encourage society to use water more efficiently with higher priority given to primary and secondary school students. In these cases, either the utilities go to the schools or they organize tours to the company's facilities, including water treatment and wastewater plants, as well as permanent exhibition spaces, for schools but also for other sectors of society.

As far as advertising campaigns and other promotional activities are concerned, the utilities have invested fewer resources to promote water-saving technologies in the householdss, and therefore, the

impacts of these measures are presumed to be weaker. In this regard, the initiative of some local councils of passing regulations on building codes for new and renovated premises, have probably been more decisive. It is not uncommon for new or renovated building to be mandated to install water-saving flow regulators or water flow reducers, and dual-flush toilets.

A very important measure has also been on installing individual metres. A first step has been to replace communal water meters, which in the past were installed in blocks of homes, with individual water meters. This ensures that the neighbours become responsible for effective domestic water consumption, and therefore only pay for what they really consume. A second step has been to replace the old water meters with electronic meters that offer more accurate, remote, real-time readings. In Barcelona, when excessive water consumption is observed using remote real-time readings from the premises of the company, the client is contacted. Informing the client as soon as readings of excessive consumption are received means that a broken pipe can be quickly repaired.

The findings in this paper are based on a ranking of measures as perceived by the water utilities, and hence it is qualitative, and to some extent, subjective in nature. Measuring impacts quantitatively would provide more definite answers, though there are methological issues, such as how to objectively measure impact of awareness campaigns, which may only show effect in a longer term, while at the same time there are many other factors impacting water consumption. Yet, as many resources are spent on campaigns, not only in Spain and for water, their impacts should be significant enough for organizations to be convinced of their results.

6. Conclusions

There is a growing concern to make more efficient and sustainable use of water resources, and this preocupation is greater in geographical regions suffering of high-water stress. The experience of these cities and regions, such as the ones discussed in this paper, will be useful to other ones that decide to become more efficient and follow more sustainable practices.

Our study analyses several measures aimed at improving the efficiency of water use by reducing water consumption per capita in households. It focused on the set of measures adopted in five large areas of water service provision in Spain in the period 2002–2016. We had two objectives: to demonstrate which type of measures are more effective in achieving the objective of reducing water consumption per capita: pricing vs. non-pricing measures. Second, to know what measure, among the non-pricing measures, is more effective among those used by the utilities studied. Our main contribution is that, compared to studies that are based on estimates of the water demand function, in our case, we asked directly the managers of the utilities on the effectiveness of the measures.

The utilities confirmed that they had used a combination of measures within the framework of a comprehensive action plan to achieve a more efficient management of water resources at the household level. A first conclusion of our project is that, as it has been discussed previously, non-pricing measures are more effective than pricing measures to improve the efficiency in water consumption in households. On this topic, the response of the five utilities was unanimous.

Regarding the effectiveness of the non-pricing measures applied, there is was no unanimity on what measure has been the most effective in reducing water consumption per capita. In line with the Principles on Water Governance of the OECD (2015, 2018), we agree that the specific context of each case is a very important precondition. For example, in some of the cities studied, the large number of collective meters that have been replaced by individual meters afterwards has been key.

Based on our research, we make the following suggestions. First, utilities must address water saving measures within the framework of a comprehensive action plan. Second, to achieve more efficient use of water resources, they should focus their efforts on the implementation of non-pricing measures. Third, taking into consideration the experiences on other geographical areas, the decision on the measure or measures to be implemented should consider the local contexts and be adapted accordingly. Finally, it is advisable that educational campaigns are implemented on permanent basis, mainly targeting the young population.

In the future, it would be desirable to undertake research that, within the same areas we have studied, is able to quantify and compare the effectiveness of different non-pricing measures to reduce water consumption per capita. In addition, although the impact of pricing measures is less compared to non-pricing measures, it would be desirable to measure the impacts that per capita water consumption have during the transition of a system which tariffs are based on households to one that is based on tariffs per consumer. Finally, an issue that is not within the scope of this study due to the limitations of the sample used, but that is equally important and that should be investigated, is if private utilities invest less and undertake less initiatives to promote water savings compared to public sector utilities.

Disclosure statement

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