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In collaboration with:

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1. INTRODUCTION. PROPOSALS AND OBJECTIVES

There is much empirical evidence to suggest that water consumption has dropped over recent decades in cities in developed countries (Saurí, 2013). There are many factors that could account for this trend: greater awareness of citizens concerning the need to save water; more recurrent periods of drought; social and demographic changes; phased pricing structures with costs increasing for higher consumption; more efficient technologies; or, simply, the effects of the economic crisis and the restructuring processes of urban economies on the domestic, industrial and commercial consumption of water. Nevertheless, the importance of each particular factor needs to be evaluated by carrying out specific case studies.

This report includes an analysis of the causes of the reduction in water consumption in Spain in recent years. In order to achieve this, two empirical cases are studied, the city of Alicante and the municipalities in the metropolitan area of Barcelona served by Aigües de Barcelona, taking the years between 2007 and 2013 as a basic period of reference. As we shall see, the conclusions obtained in the two particular cases analysed can be extrapolated to most municipalities across Spain.

Given the heterogeneous nature of urban water use, a difference is drawn between household uses on the one hand, and industrial/commercial/municipal/official uses on the other. In methodological terms, we have combined a statistical analysis of the data on consumption as well as the social, demographic, economic, urban and climatological factors that may influence such consumption, with the results of a survey of major commercial, industrial and municipal/official consumers both in Alicante and in the municipalities in the metropolitan area of Barcelona served by Aigües de Barcelona.

It is important to define the different scales of work that have been followed in relation to the field of domestic consumption, which is fundamentally in line with the differences that exist between Alicante and in the municipalities in the metropolitan area of Barcelona served by Aigües de Barcelona in terms of size, population and economic and urban activities.

In the case of Alicante, the analysis of consumption trends has been carried out on a micro-scale, with invoicing data provided by Aguas Municipalizadas de Alicante, Empresa Mixta (AMAEM). The series of bills looked at (2007-2013), include water expenditure in blocks of flats with volumes broken down by households in streets and different areas of the city, which are taken to be representative of certain social, demographic, economic and income situations. On the other hand, in the municipalities in

the metropolitan area of Barcelona served by Aigües de Barcelona, which represents a much wider and heterogeneous urban space, the working scale is constituted by the municipalities, on the one hand, and, on the other, by the ten municipal districts which Barcelona is divided into.

1.1 Type of urban uses

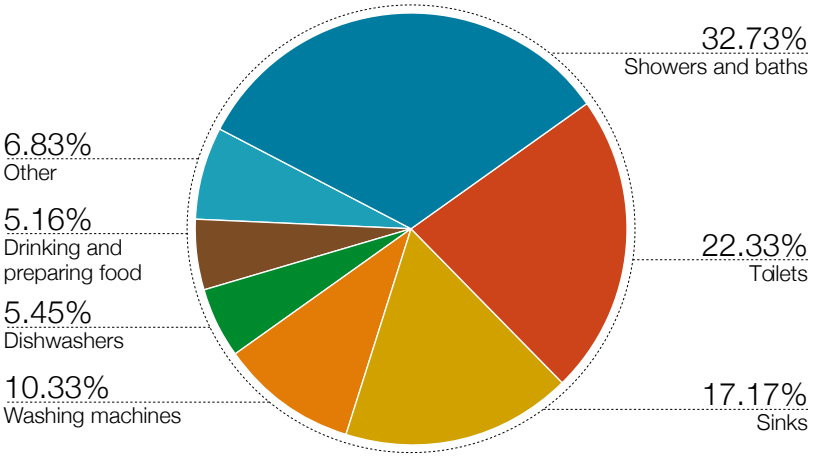
Urban uses of water represent a very heterogeneous pattern, which reflects the historical conditions of the processes of urbanisation specific to each city and dependent on the water infrastructures developed there. Conventionally, urban uses of water tend to be divided between household uses, which take place in private homes, and non-household uses, which include industrial, commercial and public usage.

Domestic use

In general, household uses of water tend to evolve in line with different levels of socioeconomic development and can vary quite significantly. The type of domestic consumption usually includes so-called indoor uses (bathrooms, kitchens, cleaning, household appliances, etc.) and outdoor ones (watering gardens, swimming pools, other ornamental uses, etc.).

In a general sense, the internal consumption of households in concentrated urban structures (apartment blocks) presents distribution levels which, broadly speaking, correspond to the following patterns of consumption:

Figure 1: Distribution of water consumption (%) in households of a concentrated typology (2013)



Source: Domene & Saurí, 2006. Compiled by the authors

In addition to these values we need to add those generated by outdoor consumption, which present notable differences depending on the urban typology in question (terraced housing with communal gardens and swimming pools or detached properties), the dominant type of garden (Atlantic or Mediterranean), and other factors such as leaks.

The variables that seem to be most influential in explaining the differences in water consumption—some of which are strongly interrelated—are income levels; the size and type of dwelling, which is a very important variable in terms of outdoor uses; age; level of education; the degree of environmental awareness; the climate; and the prices and taxes paid on water consumption.

Non-domestic use

The type of water uses in non-domestic cases depends on the main activity being carried out. These activities include commercial, industrial and public use, and can also encompass a large number of subsectors. The high degree of heterogeneity of uses included in this category makes it difficult to generalise. Furthermore, some large-scale users may have their own resources, especially groundwater supplies, whose use is not reflected in the consumption accounting.

According to the statistics, non-domestic uses of water account for 20-30% of the total urban uses, whilst domestic uses account for the remaining 70-80%. Finally, it is also important to highlight certain business strategies such as, for example, the urban relocation of industrial activities that prove to be major consumers of resources.

2. CASE STUDY: ALICANTE

2.1 Evolution of the total consumption of drinking water in Alicante (2007-2013)

The annual data on the flows supplied to the network and the volumes billed, provided by AMAEM for the city of Alicante, confirm that different stages of growth and then reduction in water expenditure can be observed during the last three decades, which can be correlated to demographic variables, urban-tourism expansion, and social and economic dynamism.

Stages in the evolution of consumptions and associated trends

In summary, and taking into account the consumption data, we can identify the following stages: 1) an appreciable and sustainable increase in consumption from 1984 to 1991; 2) a notable reduction in water use from 1992 to

1996; 3) an increase in consumption from 1997 to 2004; 4) a strong reduction in water use from 2005 to 2013.

Despite this evolution in the global water supply, the evolution of the domestic consumption data available for modules considered to be litres/person/day, litres/household/day or litres/customer/day tends to follow a structural trend of sustained reduction from the end of the nineteen nineties to the present day, even though this evolution actually accelerated from 2004 onwards, which could be related to another temporary factor which is the economic crisis suffered by Spain since 2007.

However, it should be noted that the different consumption modules, a direct result of the crisis, savings measures, etc., can be seen despite the increase in global consumption up to 2004, and the significant growth in the population up to the first few years of the recession.

The general dynamic of reduced domestic consumption since the end of the nineties could be related to other structural factors linked to technological advances in water-saving devices in bathrooms, kitchens and household appliances and, alongside this, the strong growth in personal habits geared towards saving water and using it more economically.

It is important to note that the succession of increases and reductions in consumption trends in the wholesale supply and volumes billed could be related to cycles of intense drought, such as those that occurred between 1992 and 1996 and between 2005 and 2009. However, in this case, the end of the drought in 2009 did not prompt a change in trend like the one observed at the end of the previous dry cycle. Thus, the stage that began in 2005 has lasted until 2013, and this could confirm that the factors that have led to a reduction in the demand for drinking water are of a structural and temporal nature.

The year 2004 saw the end of a stage of growth in water consumption that had started back in 1997, with the end of the intense drought experienced between 1992 and 1996. During this Iberian drought, the combination of technical improvements in retail distribution, information campaigns, the gradual implementation of water-saving devices and changes in consumption habits, among other factors, meant that the volume supplied to the city of Alicante fell from 30.8 hm^3 in 1991 to 25.7 hm^3 in 1996, representing a reduction of more than 16%. During this same period, the bills issued by AMAEM for water use also fell by 14.5%, from 24.8 to 21.2 hm^3.

A stage of sustained growth in water use started in 1997 and lasted until 2004 and 2005. In the case of Alicante, this recovery saw consumption increase from

26.7 hm^3 in 1997, to a maximum of 30.4 hm^3 in 2004, which was supplied by the Canales de Taibilla Municipal Association (26.1 hm^3) and by AMAEM (4.3 hm^3) itself from its wells in Alto Vinalopó. In 2002, reclaimed water started to be used, with 39,358 m^3 being supplied to the Alicante City Council for watering parks and gardens. From 2003 onwards this also included supply to private households.

Demographic and urban variables

There are different reasons behind the increase in water consumption during the 1997-2004 period, but a significant factor was the expansion of new areas of usage and the strong economic dynamism recorded from the mid-nineties of the last century to the financial crisis of 2007. The city of Alicante benefited from the territorial development of the province, which stemmed from traditional industries such as tourism, commerce, administration and services, agriculture for export, and the strong increase seen in the property sector and private housing construction. To this, we can also add the demographic growth recorded as a result of foreign immigration and the strong expansion of tourist and residential services and functions.

Evolution of water supplied

Another very important variable comes into play in the evolution of water usage, and that is the number of customers connected to the supply network. At the same time, this number is directly related to existing households in addition to the contracts linked to the non-domestic sector (industry, commerce and public services). Between 1999 and 2006 there was a 17.61% increase in the number of registered customers, whilst between 2006 and 2013, the number of registered customers barely increased by 4.96%, from 188,990 contracts to 198,372, while the volume supplied to the network dropped from 28,567,075 to 22,308,699 m^3, which represents a reduction of 21.9% during the period indicated.

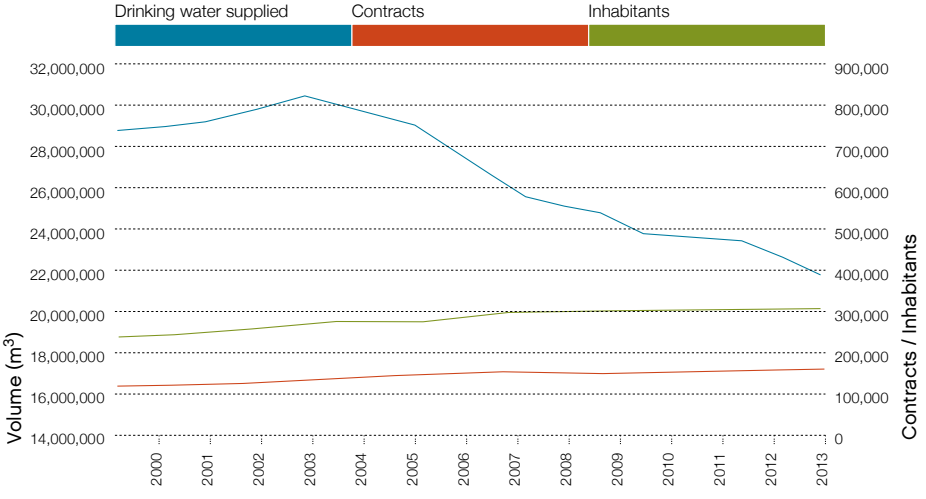
This minimum growth in the number of registered customers during the period 2006-2013 compared with the seven previous years can be added to the causes that have had an impact on the significant reduction in consumption.

Table 1. Evolution of the supply of drinking water in Alicante (2006-2013)

Town	COMPANY	Year 2006		Year 2013	
		Supply (m^3)	NO. of registered customers	Supply (m^3)	No. of registered customers
Alicante	AMAEM	28,567,075	188,990	22,308,699	198,372

Source: AMAEM, 2014.

Figure 2. Annual evolution of contracts, inhabitants and water supplied in Alicante (2000-2013)

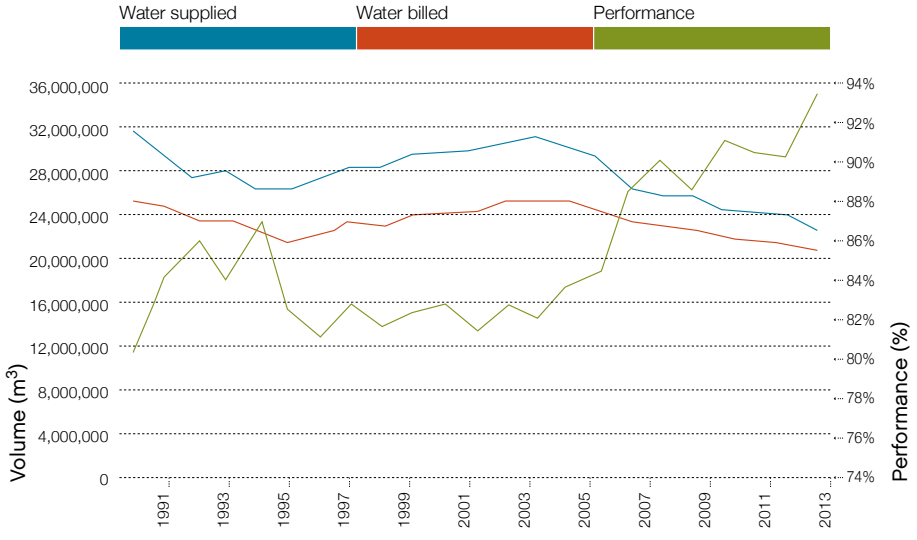


Source: AMAEM, 2014.

One of the factors that has contributed to a significant reduction in the volume of wholesale water supplied has been the improvements made in the technical areas and management systems implemented in retail distribution within the city of Alicante, in order to increase the hydraulic performance of the distribution network and the volume of water recorded as revenue and billed. These advances have also been extended to the complete water cycle, with very important improvements in the area of sewerage and wastewater treatment, and the reuse of reclaimed water. The control of water registered with users and non-revenue water must be improved in order to improve the hydraulic performance of the distribution network. This hydraulic performance depends on numerous variables, although the most important are the length of the distribution network, its age, state of conservation, number of connections, and the accuracy of the consumption meters to avoid utility 'submetering' and fraud.

Improvements to the retail distribution network and, consequently, increases in the efficiency of the network, are some of the reasons behind the reduction in the water consumption supplied to the network. Improvements in the efficiency of the network are reflected in the performance of the distribution network, which has gone from 80.49% in 1991 to 92.88% in 2013; reaching values higher than 85% on a continuous and uninterrupted basis since 2006 (Martínez, 2010).

Figure 3. Water supplied, water billed and performance levels in Alicante (1991-2013)



Source: AMAEM, 2014.

2.2. Evolution of domestic consumption in Alicante (2007-2013)

The demand for water in urban spaces depends on a combination of different factors and components. However, the most important factors are the following: population served (permanent and seasonal); city model (disperse or concentrated); number and types of households served (in blocks, detached, etc.); number of industries and activities developed; number of commercial premises; municipal consumption (gardens, street cleaning, schools and other public buildings, etc.). In addition to the typologies of the units of demand, other decisive factors are the dynamism of the economy, pricing policies and, above all, the measures for managing and saving water in consumption habits.

General evolution trends in the domestic sector

The cycle of drops in consumption in the domestic sector started in 2004 and 2005, as already noted, accumulating a 14.2% decrease in the volume billed up to 2013. However, the reduction of the use of water contrasts with the growth in the number of contracts, caused by the inertia in the promotion of housing delivered, the construction of which began in previous years. In effect, since the start of this period and up to 2013, the number of

registered customers in the municipality of Alicante increased from 160,352 to 177,422, which represents an increase of 10.6%.

While this trend in the reduction of volumes of drinking water billed from 2004 and 2005 in the municipality of Alicante is due to a combination of interrelated causes, the following stand out as being the most significant determinants:

a) Lower demographic growth after the years in question. Thus, during the period 2005 to 2013, the population of Alicante grew by 15,187 inhabitants, whereas it had grown by 41,830 inhabitants in the period 2000 to 2005. This demographic trend is also related to the question of settlement and particularly to the slow-down of the urban residential expansion that took place from 2004 and 2005, followed by a complete paralysation of property-related business from the outset of the financial crisis in 2007.

b) The implementation of water-saving devices and more efficient household appliances in homes. On top of this we can also add the gradual and permanent development of consumption habits aimed at saving water that have been growing in popularity since the middle of the last decade, and which have intensified even more as a result of the economic crisis from 2007 onwards.

c) Reduced occupancy of dwellings. On the one hand, this is in relation to vacation homes where the economic crisis has been noted in the reduction of the traditional holiday periods; on the other hand, many buildings and dwellings built during the property boom have not taken up the expected contracts for drinking water supplies.

d) Efforts to promote the reuse of treated wastewater in the city of Alicante and its surrounding metropolitan area, in order to replace the consumption of white water used to water parks and gardens with reclaimed sources.

Figure 4. Evolution of domestic consumption (m^3) and the number of contracts held in the city of Alicante (2000-2013)

Source: AMAEM, 2014.

Table 2. Evolution of domestic water consumption, population sector and supply contracts in the municipality of Alicante (2000-2013)

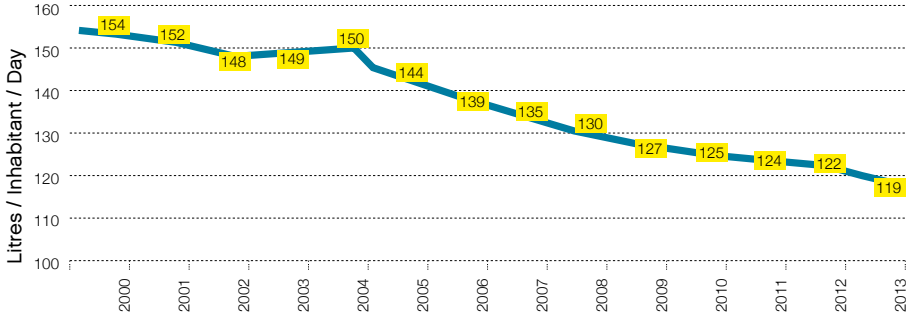
Population sector:	YEAR			
	2000	2005	2010	2013
National	273,742	283,755	284,077	285,881
Foreign	6,069	37,886	51,382	50,947
Total	**279,811**	**321,641**	**335,459**	**336,828**
Water consumption	**15,582,916**	**16,767,442**	**15,287,578**	**14,518,418**
NO. of contracts	**144,202**	**164.112**	**175,979**	**177,422**
Consumption (litres/contract/day)	**296**	**279**	**238**	**224**
Consumption (litres/inhabitant/day)	**154**	**144**	**125**	**119**

Source: Municipal Register of Inhabitants and AMAEM, 2014.

In spite of this, from 2004 and 2005 the drop in individual consumption modules accelerated to the point that in 2013 the average consumption module of residents in Alicante stood at 119 litres/inhabitant/day, in contrast to the 154 litres/inhabitant/day recorded in 2000. This represents a reduction of 22% for the period in question.

It should be noted, however, that the reduction of these consumption modules seems to have been mitigated somewhat over recent years. This moderation in the downward trends in these modules could indicate that we are close to reaching the maximum threshold point in terms of the savings that can be obtained through the technical devices installed in bathrooms and showers, the more efficient household appliances, and the new personal consumption habits.

Figure 5. Annual evolution of domestic consumption (litres/inhabitant/day) in Alicante (2000-2013)



Source: AMAEM, 2014.

Urban expansion and type of dwelling

An important factor to take into account in explaining the evolution of drinking water consumption during the last three decades in the city of Alicante is the considerable expansion of the uses made of urban and residential land. This process has meant that the surface area of urban and residential land almost tripled between 1978 and 2013. There were two large-scale expansion stages during this period, which coincided with certain cycles of growth in the consumption of drinking water. The first of these, from the end of the seventies to the beginning of the nineties, saw urban growth on existing land spread across the traditional city and the neighbourhoods of La Florida, San Blas, Rabasa, Tómbola and Los Ángeles.

The second phase of strong urban expansion is linked to the boom in the construction industry and the property market that took place from the mid-nineties up until the financial crisis which began in 2007. This phase coincided with the cycle of growth in drinking water consumption in Alicante and is closely tied to the intense movements in the property sector that the city saw from 1996 to 2007.

Table 3. Evolution of the use of urban and residential land in the municipality of Alicante during the period 1978-2013

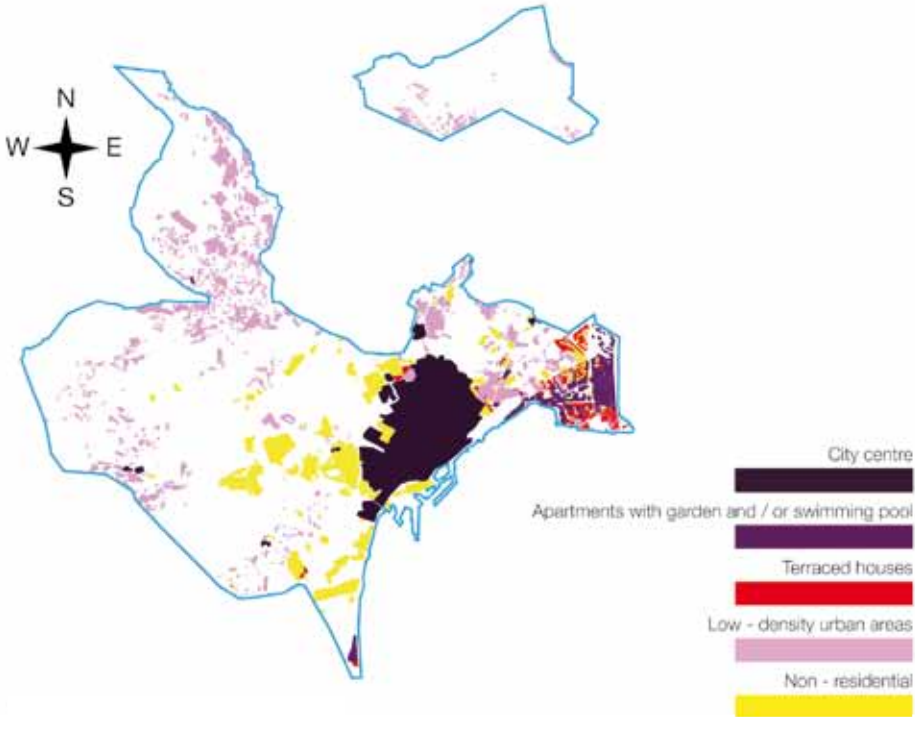
	1978		2013	
	m²	%	m²	%
City centre	8,701,774	53.49	14,416,012	31.41
Apartments with garden and/or swimming pool	1,149,268	7.06	2,968,448	6.47
Terraced houses	67,842	0.42	1,640,775	3.58
Low-density urban area	2,622,466	16.02	15,801,972	34.43
Non-residential urban land	3,726,248	22.91	11,064,360	24.11
Total	**16,267,598**	**100**	**45,891,567**	**100**

Source: Morote Seguido, A. 2014.

The phase of considerable urban expansion seen in 1996-2007 favoured the expansion of buildings with communal gardens and swimming pools which were built on the outskirts of the city, in particular the Babel and San Blas industrial estates, Altozano, the new zone in Los Ángeles, Lo Morant-Ciudad Jardín, Gran Vía, and the new zone of Garbinet, among others.

Other areas that have seen considerable expansions in urban and residential uses in this second phase have been the beach zones in La Albufereta, Cabo de La Huerta, Playa de San Juan, La Condomina and Urbanova. The construction of apartment blocks with gardens and/or communal swimming pools has been dominant in these areas, although we can also see other urban models in these zones, such as El Cabo de la Huerta and La Condomina (Alicante Golf), where we often find terraced-style housing and detached houses, sometimes with gardens and private swimming pools, which push up individual consumption modules of drinking water usage. It is also worth highlighting the large expansion of the diffuse and low-density urbanisation model that has been seen in rural parts of Alicante (La Cañada del Fenollar, El Verdegas, El Moralet, La Alcoraya, El Rebolledo and El Bacarot), where we tend to find houses built on old agricultural plots that have gardens, swimming pools and even small vegetable plots for personal consumption.

Figure 6. Typology of the different uses of urban and residential land in the city of Alicante in 2014



Source: Morote Seguido, A., 2014.

The urban development of recent decades has led to the expansion of the tourist and residential seasonal population, which has important repercussions on drinking water consumption.

Table 4. Evolution of the number of homes in the municipality of Alicante (1991-2011)

	Main	Seconds	Empty	Total
1991	82,695	33,252	15,791	131,738
2001	103,293	28,663	21,060	153,016
2011	132,637	28,707	25,172	186,516

Source: INE, 2014

Furthermore, as well as impacting on seasonal consumption, second homes also have a decisive effect on the reduction of the average consumption

modules in litres/household and in litres/contract/day. And the same occurs with empty dwellings which, in the case of Alicante, have grown significantly over the last two inter-census periods (1991-2001 and 2001-2011).

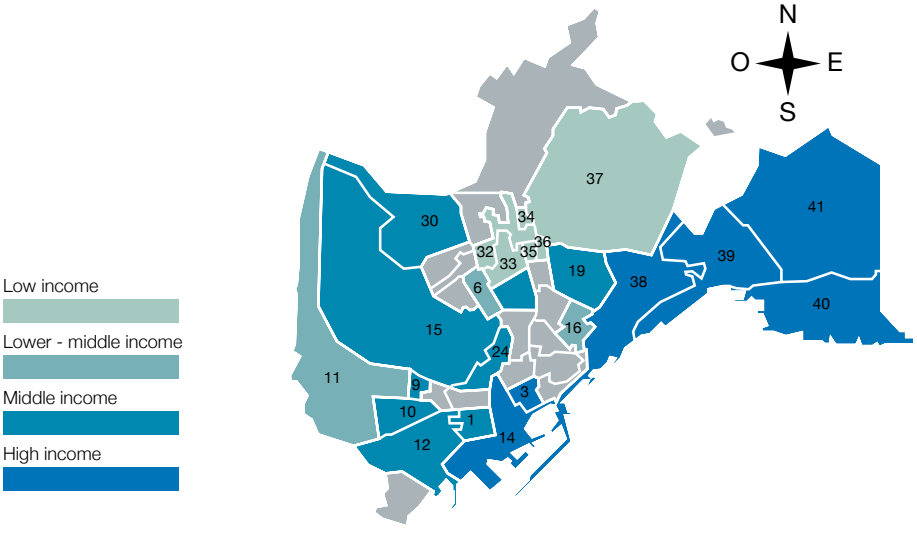
Reduction of consumption and the socioeconomic differentiation of urban space in Alicante by neighbourhood

Water consumption, being somewhat in line with income levels and, thus, related to the quality of the dwelling, its sanitary provisions, green spaces, swimming pools and other possible facilities, which depend upon the purchasing power of the owner, is a very good indicator that can help us to understand the social differentiation of spaces. If, as is the case in question, a general downward trend towards a reduction in drinking water consumption is detected, this differentiation constitutes an essential reference point to be able to understand and contemplate the different reasons or, in any event, the importance of each of these reasons, even in terms of their structural or temporary nature, which may depend on the income available, and which may have been affected to a greater or lesser extent by the current crisis. It also makes it possible to ascertain the extent to which this may or may not have had an effect on standards of living, or, in many cases, subsistence levels, with the adoption of strategies or actions to reduce water costs.

These considerations appear to be particularly relevant in the case of the city of Alicante, where to speak only of social differentiation in the urban sector would be grossly misleading, since there has been a clear and growing phenomenon of segregation in this area over recent times, with the presence of poor and disintegrating neighbourhoods in marginal areas and degraded sectors of the historical centre, which is losing its place as a traditional neighbourhood to the benefit of new neighbourhoods (San Blas industrial estate, Garbinet and Playa de San Juan).

Four income thresholds have been defined in order to establish typical behaviour patterns for the different social groups: low, lower-middle, middle and high incomes, with respective thresholds of 25,000, 50,000, 100,000 and over 100,000 euros, and with the different classes being configured in line with these thresholds, taking average income to be an annual gross figure of between 50,000 and 100,000 euros.

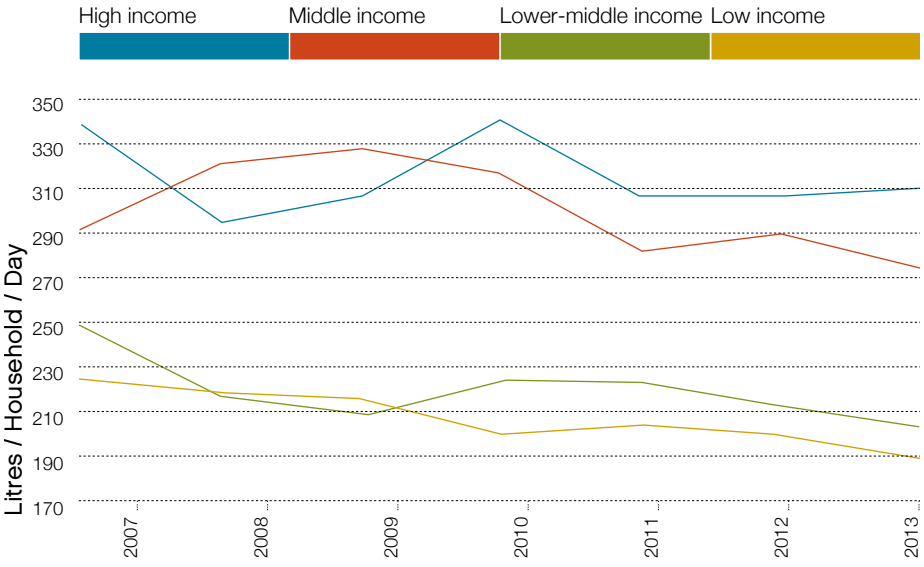
Figure 7. Districts with buildings selected to analyse water consumption by groups of low, lower-middle, middle and high income



Source: AMAEM. Compiled by the authors, 2014.

Another point worth mentioning is that some residences in marginal or impoverished urban areas with cramped housing conditions show unusually high cases of water consumption (samples from Virgen del Remedio and Virgen del Carmen, which are higher than 400 litres/household/day), which are often caused by over-occupation, given the relatively high number of persons living there from different families and, at the same time, without family ties. In this sense, the data goes hand in hand with per capita data which is also notoriously low in these cases (Figure 8).

Figure 8. Evolution of water consumption according to income levels



Source: AMAEM. Compiled by the authors, 2014.

New technologies have very little influence on reductions in the consumption observed in areas with fewer resources. This is in contract to the situation in middle- and high-income cases where these improvements constitute a structural cause of reductions in water use.

The impact of the demographic factor

A final element to consider as a factor which could reduce water consumption in the future is the declining population. In contrast to the notable period of demographic growth registered in coastal and pre-coastal municipalities in the inter-census period of 2001-2011, and in which the city of Alicante is no exception, mid-term population estimates (2012-2022) compiled by the National Statistics Institute (INE) show a shift in demographic dynamics. The ageing population, together with the rate of immigrant populations returning to their country of origin and the migration of local populations in search of work, are the main causes underlying the fact that Alicante estimates a population loss of 19,658 inhabitants between 2012 and 2022 (INE, 2014c). If this quantitative data proves to be relevant—understood, that is, as units of demand—other qualitative questions related to the typology of the population in question should also prove to be of interest. The ones returning to their country of origin tend to be young people or sometimes whole families with children, whose water consumption is greater than the

ageing population, which tends to be associated with lower consumption figures. Nauges and Thomas (2000) and Troy et al. (2005) argue that water consumption in households where there are younger people is higher in comparison to those with older people, since younger people shower more frequently and tend to show higher consumption levels of outdoor uses for leisure purposes (March & Saurí, 2009).

Along similar lines, other publications suggest that older people are more conscious of the need to save on water consumption (Mayer et al., 1999). The average size of family units may also impact on domestic consumption. According to reports compiled by the INE (2009), the average size of family units is decreasing. It went from being 3.4 members in the nineteen eighties to 2.9 in the first decade of the 21st century and is a factor that could result in shrinkage of consumption. However, the opposite effect could also arise from the increase in family units made up of one sole individual. Höglund (1999) indicates that households inhabited by one sole person consumed 41% more than those inhabited by two people. The inefficiency of certain practices and the economies of scale explain these greater levels of consumption (Cubillo et al., 2008).

Generalisation of water-saving devices

One of the key factors from the point of view of the reductions achieved in consumption levels is related to the introduction and subsequent dissemination of technical innovations, both in terms of tap systems and household appliances. The introduction of mixer taps from the nineties and their widespread implementation—since they are not only present in building constructed after the late nineties but are also a constant feature in renovation works carried out on old buildings—has represented a significant saving in all activities related to tap use (from domestic hygiene to the preparation of food). Different studies insist on the ecological function of these devices, providing evidence that these kinds of taps consume less than 8 litres per minute for operational pressures of 1 to 3 bar, and less than 9 litres if the pressure is between 3 and 5 bar.

Starting at the beginning of the 21st century, new water-saving devices, such as flow limiters or restrictors and aerators, have been introduced to complete this system. Thus, the combination of mixer systems with flow restrictors or aerators results in savings of 50% in consumption from taps.

Important developments have also been seen in the technical innovations related to toilets which, alongside the personal hygiene associated with their use, are responsible for between 50 and 60% of domestic consumption. The

generalisation of toilet systems with dual flush systems, which allow the user to choose the quantity of water necessary in each case (flushes of 3 or 6 litres, for example) as opposed to the volumes of between 5 and 9 litres of conventional systems, has also led to significant reductions in consumption. The savings generated by this system have been complemented over recent years with the introduction of systems that limit the filling of the tank or that have counterweights that reduce the quantity of water dispensed by the tank.

Notable technical innovations have also been applied to household appliances (washing machines and dishwashers), which are responsible for around 20% of domestic consumption. Improvements in efficiency in terms of both energy savings and water consumption stand out in terms of the technical improvements made in appliances over the last fifteen years. During this period, the incorporation of eco programmes, short-wash programmes and the standardised use of energy efficiency labels on household appliances (Regulation (EU) No. 1059/2010) have meant a saving of around 40% of the water and electricity consumption generated by these appliances.

The widespread introduction of water-saving systems in taps, toilets and household appliances is related to a third structural cause that has impacted on the on-going process of reducing water consumption per inhabitant/day.

Evolution of prices and water bills

The increase in water prices has been considered as a tool to control consumption (Sánchez & Blanco, 2012). The implementation of the Water Framework Directive, which enforces the adoption of pricing systems that recover the costs of water resources and establish pricing policies in order to promote sustainable uses of water, has led to increases in the cost of water. This increase has been one of the causes —although not the only one—that explains the reduction in European consumption figures (Environment Agency, 2008).

An analysis of the evolution of prices paid for water is complex given the different aspects covered by the overall water bill (consumption fee; sewerage treatment and network tax). A differentiated analysis of each of the aspects covered by the water bill indicates a different evolution of the costs associated with each of these aspects.

In relation to water, the rises recorded do not reflect a linear increase but relate, instead, to significant differences according to consumption blocks

(Table 5). The price paid per cubic meter in the first threshold (up to 9 m^3 per quarter) has not increased since 2007. By contrast, the increase in the other blocks is progressive (between 23 and 45%). The increase observed in the last block clearly reflects the aim to deter and control consumption manifested in the price of water.

Table 5. Increase in water prices in Alicante (2007-2013). Household rates

Price	% increase 2007-2013
From 0 to 9 m^3 per quarter	**0.00**
From 10 to 30 m^3 per quarter	**23.25**
From 31 to 60 m^3 per quarter	**35.38**
From 61 m^3 upwards per quarter	**44.78**

Source: AMAEM. Compiled by the authors, 2014.

The price increase associated with the Government of Valencia's sewerage treatment tax should also be noted which, for a bill of 30 m^3, has meant an increase of 36.98% in service charges and 35.07% in consumption charges for the period studied (2007-2013). Similarly, VAT charges have increased to 26.02% for the same bill during the same period.

Increases in the final price of water bills during the period analysed (2007-2013) are clear. Their increase may have contributed towards shrinking consumption levels; although this is due to a combination of different factors, some of which have already been mentioned above.

It should also be noted that in 2006, Aguas de Alicante started a special investment plan for drinking water, sewerage and reuse, with an approximate investment of €55,000,000. Furthermore, and within the section of discounted prices, in 2013 the number of large families who benefited from discounts awarded by the company rose to 812, with a value of approximately €25,700. Also in 2013, the social fund used to discount water bills for disadvantaged groups subsidised 697 families in Alicante, to a total cost of €146,948. .

Among the different temporary causes of reductions in consumption, we should also mention the economic crisis. Increases in the final bill paid by the user, together with the consequences of the current economic situation which, to simplify considerably, can be summed up in increases in unemployment and reductions in salaries that generally affect the middle- to low-income scales, have led to the adoption of measures aimed at cutting

household expenditure, with one of these measures including reductions in water consumption in order to cut down on bills.

Different elements corroborate these conjectures in the city of Alicante. First, the fact that the average consumption per household, taking into account the different typologies, stood at 703 litres/household/day in 2007, in contrast to the 434 litres in 2013. Second, consumption increases in the first tranche of the household pricing scale (corresponding to the lowest prices that have shown no increases since 2007) in comparison to the other tranches, where decreases are notable and particularly intense in the last two tranches (Table 6). We thus find that consumption trends are shifting towards the lower tranches.

Table 6. Evolution of consumption (m^3) per block. Household rates

Tranches	2007	2008	2010	2013	% increase 2007-2013
From 0 to 9 m^3	4,451,596	4,635,957	4,726,855	4,765,604	**7.05**
From 10 to 30 m^3	6,468,340	6,467,004	6,343,437	6,040,576	**-6.61**
From 31 to 60 m^3	2,330,702	2,223,655	1,952,731	1,645,166	**-29.41**
Over 61 m^3	2,472,988	2,436,436	2,253,510	1,905,097	**-22.96**
Total	**15,832,986**	**15,763,052**	**15,276,533**	**14,356,443**	**-9.32**

Source: AMAEM. Compiled by the authors, 2014.

Impact of elements related to the climate

In spite of the fact that studies carried out up to now have not provided conclusive findings that would allow us to quantify with precision the extent to which the climate impacts on drinking water consumption patterns—in isolation from other factors—we think it would be highly useful to evaluate its impact in any future studies carried out on consumption.

Along these lines, the negative deviation of the water supplied to the city of Alicante from February to December 2013 in comparison to the same months of the previous year was considerable, with percentages of between 3.83 and 5.54; and it is possible that the reduction in consumption referred to could be related, at least to some extent, to meteorological circumstances. From this perspective, and in a more notable sense, we observe that average temperatures in the months of May, June, July, August, November and December of 2013 were between 0.4 and 2.8°C below those of 2012, being considerably milder than in 2012. We also note that very little rain was seen in the late summer and autumn months of 2013; only 11.40 mm from September to November (3.00 in September, an almost non-existent 0.10 in October, and 8.30 in November): in other words, a dry

autumn. Despite this, temperatures in November were lower than those in 2012, which calls to mind situations in the West with light rainfall and lower temperatures, cloudy skies, less sun and generally poorer weather conditions, which are not at all conducive to water consumption.

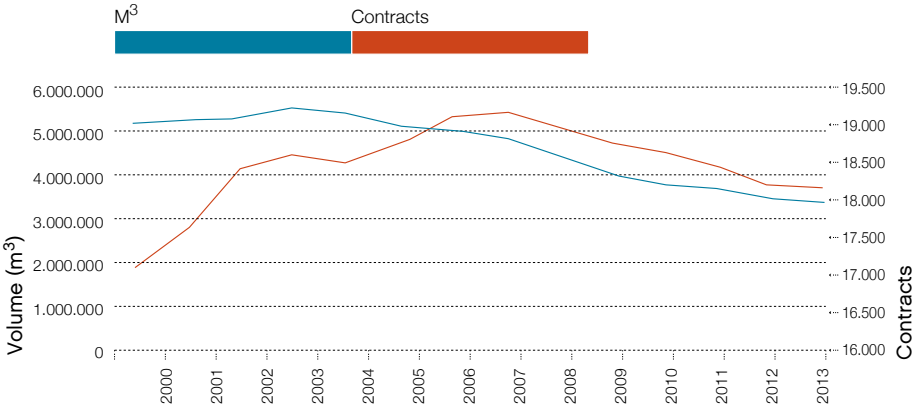
Up to now, the scarce data available, which is constrained to the comparative analysis of 2012 and 2013, does not allow us to make further observations on this matter. But if we look at the general effects, there is little doubt that the determining effect of meteorological conditions, and of the weather in general in a city with a generally comfortable climate such as Alicante, is a variable which should be clearly analysed in depth in relation to the evolution of water consumption in the period studied, when situations arise with more frequent cases of unsettled weather, with scarce rainfall but cloudy skies, and which contrast sharply with the clear skies which are more common in this city.

2.3 Evolution of non-domestic consumption in Alicante (2007-2013)

Evolution of commercial/industrial activity

The reduction of drinking water consumption in the city of Alicante has affected both the domestic sector and the non-domestic sector, although some differences and nuances in this evolution should be noted. The drop in the volume invoiced in the non-domestic sector (excluding official and municipal customers) started in 2003.

Figure 9. Evolution of domestic consumption (m^3) and the number of contracts held in the city of Alicante (2000-2013). Excluding official and municipal customers



Source: AMAEM, 2014.

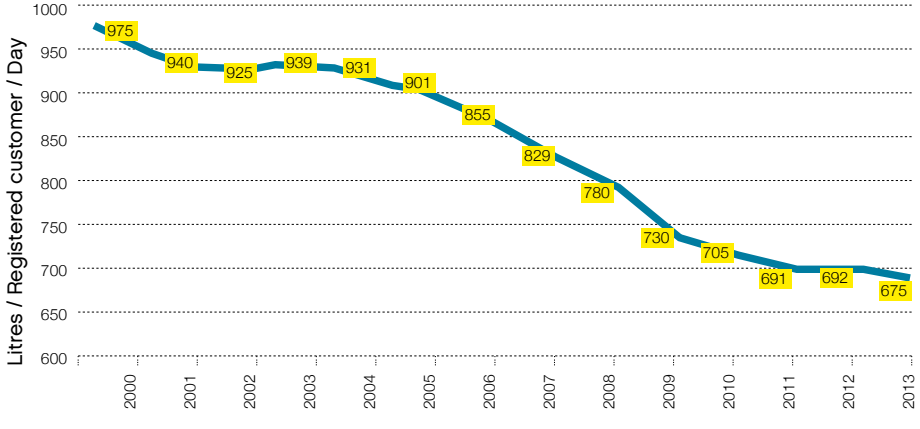
Table 7. Evolution of number of supply contracts and water consumption per sector in the municipality of Alicante (2007-2013)

Sector	Number of contracts		Consumption in m³	
	2007	2013	2007	2013
Domestic	170,395	177,421	15,832,628	14,513,745
Commercial	18,174	16,984	2,981,062	2,227,722
Industrial	775	714	1,313,333	695,649
Municipal	939	992	1,207,608	1,250,729
Other	1,798	2,261	1,496,773	1,380,131
Total	192,081	198,372	22,831,404	20,067,976

Source: AMAEM, 2014.

A considerable reduction has been seen in Alicante in terms of the number of registered customers in the commercial and industrial sector since 2007, coinciding with the start of the economic crisis. In this year, 18,949 contracts were held, in contrast to the 17,698 contracts of 2013, representing a reduction of 6.6% in the number of customers. However, the extraordinary and outstanding reduction—equivalent to 32%— in these customers' consumption for this same period is even more relevant. The effects of the economic crisis on the commercial, restoration and service sectors of the city of Alicante, which has led to the closure of many businesses, is evident in this downward trend, which affects both volumes billed as well as numbers of customers.

Figure 10. Annual evolution of non-domestic consumption (litres/inhabitant/day) in Alicante (2000-2013)



Source: AMAEM, 2014.

Furthermore, the reduced economic activity, the implementation of water-saving devices, the rise in prices, the use of other sources of water such as reused water or groundwater, and the introduction of more efficient production processes in water use would also explain another important factor, which is the considerable drop in the water expenditure module measured in litres/registered customer/day in these consumption units, which has plummeted from values of 939 litres/registered customer/day in 2003, to 675 litres/registered customer/day in 2013.

The loss of economic activity in Alicante and its metropolitan area has also been felt in terms of the industrial and logistics services carried out in the industrial estates of Atalayas, Babel and Pla de la Vallonga, and this has resulted in a notable reduction in drinking water consumption.

Table 8. Evolution of volume billed in the industrial estate of Pla de la Vallonga (2006-2013)

	Year	
	2006	**2013**
Total (m^3)	194,315	134,748

Source: AMAEM, 2014..

Evolution of reclaimed water

Another factor which has played a role in the reduction of drinking water for some urban uses, particularly in the watering of parks and gardens, is the expansion of networks and areas where treated wastewater is used and which AMAEM has distributed to private customers such as the Alicante City Council since 2002. The greatest advancement seen in this non-conventional source took place during the last drought of 2005-2009, when its consumption increased significantly. In 2007, for example, the use of this type of resource amounted to a total volume of 432,247 m^3, of which 180,378 m^3 was supplied to the City Council and another 250,869 m^3 to private customers. In 2013, the consumption of reclaimed water in the city of Alicante grew to 1,050,063 m^3, of which 587,357 m^3 was supplied to the City Council and 462,706 m^3 to private customers. This strong rate of growth is also evident in the evolution of the number of contracts signed by AMAEM with the City Council and individual customers, which grew from 8 in 2007 to 90 in 2013, particularly in low-density urban areas that have increased their consumption of reclaimed water for watering gardens and allotments.

This initiative, which Aguas de Alicante has driven forward in an effort to extend the networks of treated wastewater across the city and the metropolitan area of Alicante, breaks new ground in Spain and constitutes an example of how to maximise efficiency in the complete management of the resource, by replacing the white water consumed for watering with treated and reclaimed wastewater.

A driving factor behind this expansion is the considerable difference in current prices between reclaimed water, which was distributed in 2013 at €0.32/m^3, and drinking water which, for a consumption of 30 m^3 per quarter, may amount to average costs of €2.23/m^3, with the respective charges for conservation, the sewerage network and sanitation, plus the taxes included in these charges which the supplier must pass on to customers.

Table 9. Evolution of reclaimed wastewater and drinking water consumption at private properties in the Vistahermosa area (2007-2013)

Year	Reclaimed water (m^3)	Drinking water (m^3)	% of reclaimed water consumed
2007	1,830	152,334	1.19%
2008	4,544	154,756	2.85%
2009	30,109	129,793	18.83%
2010	56,750	139,443	28.93%
2011	50,380	138,332	26.70%
2012	70,534	118,228	37.37%
2013	85,644	120,124	41.62%

Source: AMAEM, 2014.

3. CASE STUDY: MUNICIPALITIES IN THE METROPOLITAN AREA OF BARCELONA SERVED BY AIGÜES DE BARCELONA

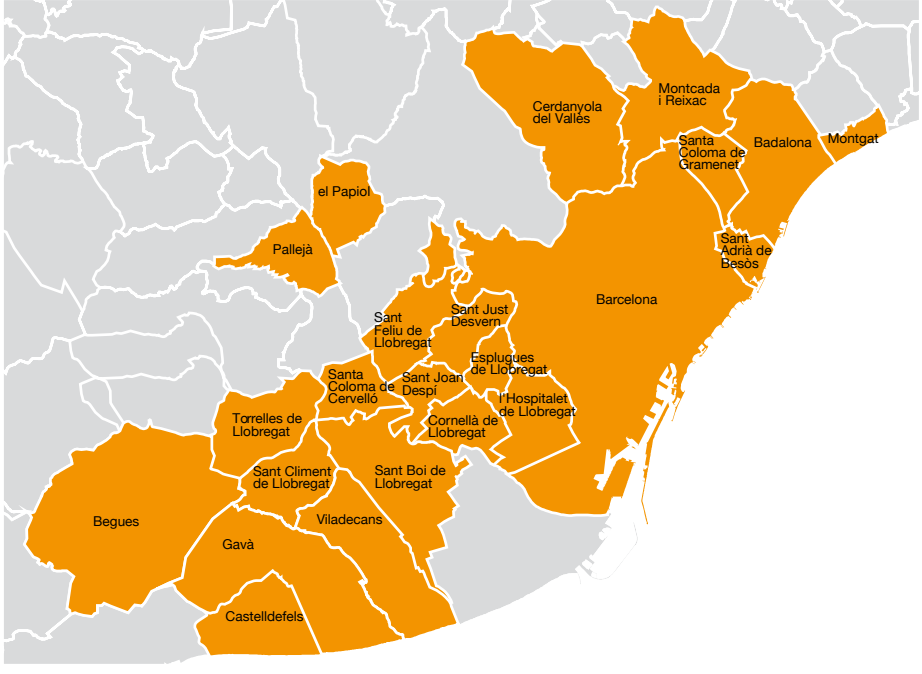
3.1 Evolution of total drinking water consumption in the municipalities in the metropolitan areas of Barcelona served by Aigües de Barcelona

In 2013, the population of the metropolitan area of Barcelona supplied by Aigües de Barcelona (23 municipalities) amounted to 2,868,692 persons, i.e. 1.9% more than 2007. This slight increase in population, however, displays major variations in its distribution within this territory. Thus, the highest percentage increases are located in small towns on the periphery, such as Torrelles de Llobregat or Begues, while the large metropolitan municipalities have seen very little growth. Even without the impetus of previous years, these figures appear to confirm the already observed trend in the

movement of the population from compact urban environments (Barcelona and its urban continuum) to peripheral environments with the predominance of more dispersed urban areas and, therefore, the greater weighting of outdoor uses of the water, such as gardens and swimming pools.

Figure 11 shows the municipalities of the Barcelona metropolitan area supplied by Aigües de Barcelona, which form the subject of this study.

Figure 11. Municipalities of the Barcelona metropolitan area supplied by Aigües de Barcelona



Source: Municipal Map of Catalonia, ICC. Administrative limits of Barcelona, Barcelona City Council.

The metropolitan area of Barcelona has always been characterised by a relatively modest domestic consumption of water, which contrasts with other Spanish cities and, of course, is very different to other cities with similar climatic characteristics such as the western U.S. or Australia. In large part this is due to the prevailing urban model in the city (the urban density is one of the largest in Europe) and in the neighbouring municipalities, characterised by high-rise housing with relatively small surface areas and very basic facilities (usually a single toilet, sink and shower) and occupied by families consisting of several members.

Therefore, most of the household uses of water in Barcelona and its immediate surroundings are indoor and very basic uses. This model began to experience significant changes from the mid-1980s with the loss of population in the denser metropolitan cores and the rise of the population in the peripheries. These metropolitan migrations also spurred the growth of low-density urbanisation in the periphery and, thus, significantly altered the nature of domestic water consumption by creating numerous single-family homes with gardens and private pools or collective ones with the same services.

The evolution of domestic water consumption in this territory over the past 20 years has been characterised by a certain degree of growth from 1994 to 2003, and by a decrease starting from that year, which has worsened since 2007. The peak in 2003 (143 hm^3 of household water billed for the entire operations of Aigües de Barcelona) may be partially explained by the weather that year, which saw one of the hottest summers in decades. In any case, for at least a decade the domestic consumption of the municipalities in the metropolitan area of Barcelona served by Aigües de Barcelona has been suffering continued falls in water consumption, following a trend common to most major cities in the developed world.

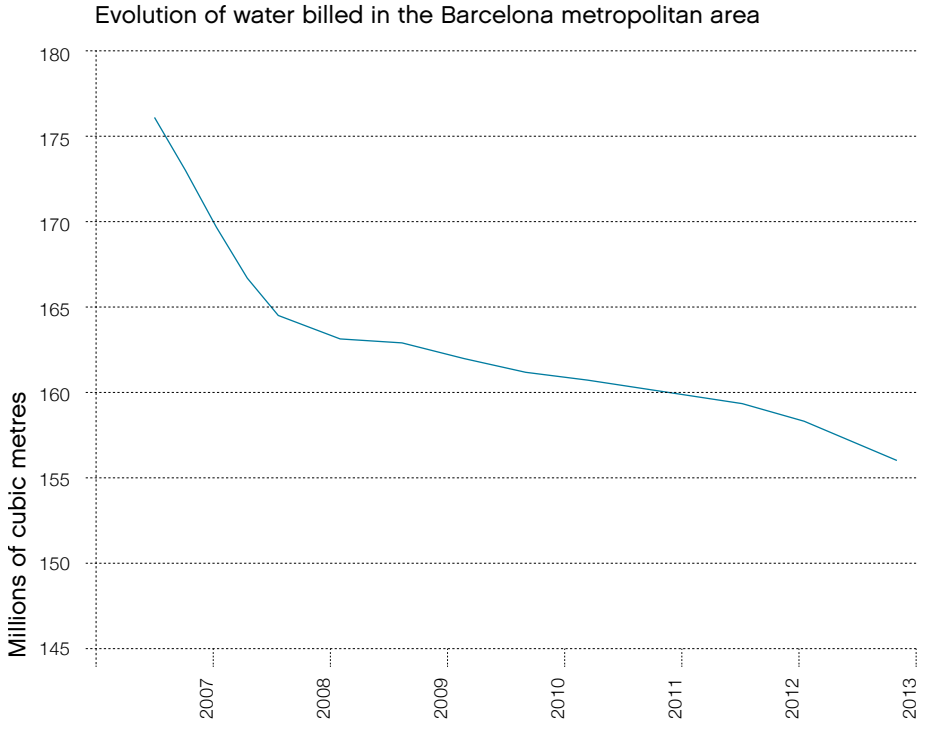
There are many causes that have been suggested to explain this decline, including more efficient toilets, showers and household appliances, but also the higher performance of the supply networks. In some cases, greater social awareness of the importance of conserving the water resource or the levying of environmental taxes and tariffs on water may have played a role. In the municipalities in the metropolitan area of Barcelona served by Aigües de Barcelona's area of operations, in addition, recent decades characterised by several droughts have also surely had the effect of instilling greater prudence in society regarding the use of this resource. Another factor that may have influenced the drop in domestic consumption could be the increasing age of the population compared to the total population in urban areas, since in principle both groups are characterised by lower than average consumption.

The aim of the research, however, has been to focus the analysis on the most recent period (2007-2013), which involves two factors, one of a more physical nature (the 2007-2008 period of drought) and the other of a socioeconomic nature which, in our opinion, may explain to a certain extent the latest water consumption trends.

Figure 12 and Table 11 show the evolution of total water consumption from the municipalities in the metropolitan area of Barcelona served by Aigües de Barcelona for the period 2007-2013. It can be seen how water consumption has experienced an 11.37% decrease over the period considered, with

some municipalities' consumption declining more than 25%, while others have values lower than 10%. Domestic consumption in 2012 accounted for 69.71%, while industrial use amounted for17.78%, commercial use, 6.66%, and municipal use, 5.85%.

Figure 12. Evolution of total water billed in the period 2007-2013



Source: Aigües de Barcelona. Complied by the authors, 2014.

Given that the sharpest declines appear to have occurred between 2007 and 2008, a period characterised by a severe drought during which a decree limited certain uses such as the cleaning of vehicles or watering of gardens, and given that 70% of the consumption from the municipalities in the Metropolitan Area of Barcelona served by Aigües de Barcelona is domestic, it should be noted that much of this reduction affected outdoor uses. This is corroborated by the sharp reductions in consumption during the summer months in some municipalities (see Table 10). Begues, for example, which has the highest per capita domestic water consumption, reduced its water consumption between June and September by more than 50% from 2007 to 2013.

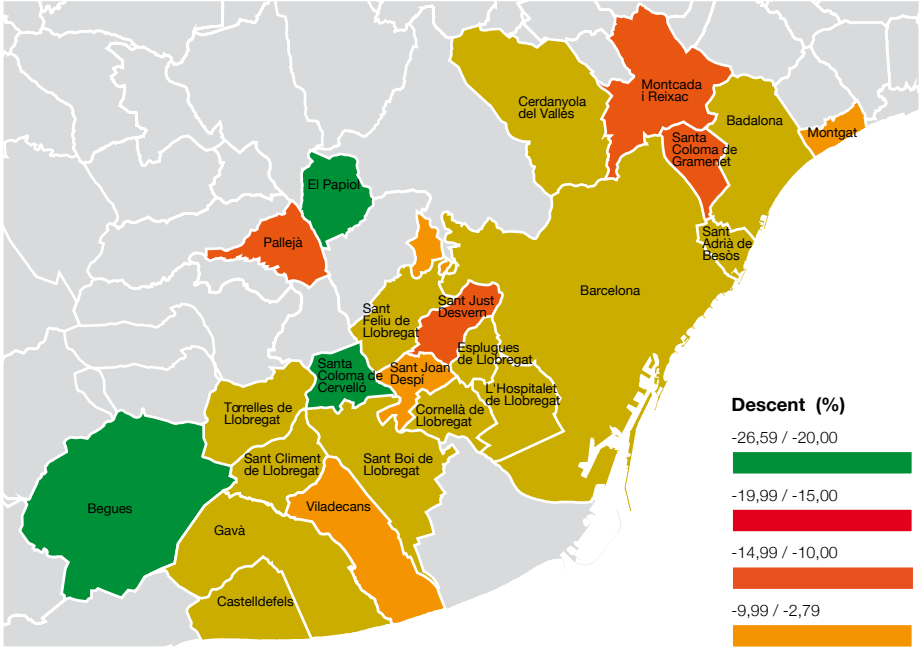
In fact, it can be seen that the percentage reduction in water billed in the warmer months (June to September) is five points higher than the reduction in the other months (January-May, October-December). Returning to the case of Begues, we note that, while consumption between 2007 and 2013 fell by 50% in the warmer months, in the remaining months the consumption in 2013 is higher than in 2007. It is interesting to note that the municipalities that recorded declines of 20% and greater (Santa Coloma de Cervello, Begues and El Papiol) are municipalities with relatively high consumption and a significant presence of low-density housing, which are more likely to have gardens and swimming pools, as we shall see in the next section.

Table 10. Change (%) in the water billed for the year and the months of June to September from 2007-2013

	Evolution (%) of annual water billed (2007-2013).	Evolution (%) of water billed June-Sept. (2007-2013).	Evolution (%) in water billed January-May/ Oct.-Dec. (2007-2013).
Barcelona	-10.12	-13.63	-8.31
L´Hospitalet de Llobr.	-14.83	-18.12	-13.14
Cornellà de Llobr.	-13.03	-21.77	-7.68
Gavà	-14.70	-4.08	-19.57
Sant Boi de Llobr.	-12.26	-17.70	-9.34
Santa Coloma de Cerv.	-22.56	-9.62	-27.86
Viladecans	-7.14	-10.42	-5.45
Castelldefels	-10.40	-20.31	-3.66
Torrelles de Llobr.	-11.88	0.11	-17.67
Esplugues de Llobr.	-9.82	-11.93	-8.77
Sant Feliu de Llobr.	-12.61	-9.27	-14.16
Sant Joan Despí	-8.74	-28.12	5.82
Sant Just Desvern	-18.37	-4.55	-24.30
Badalona	-12.38	-16.67	-10.17
Cerdanyola del Vallés	-11.29	-14.53	-9.50
Montcada i Reixac	-16.46	-14.52	-17.34
Montgat	-2.79	16.47	-10.11
Sant Adrià de Besós	-11.06	-9.35	-11.87
Santa Coloma de Gram.	-17.79	-21.30	-15.99
Begues	-26.59	-53.73	8.07
El Papiol	-23.41	-4.51	-30.83
Pallejà	-15.60	6.56	-24.45
Sant Climent de Llobr.	-10.87	8.01	-17.90
Total	**-11.37**	**-14.76**	**-9.60**

Source: Aigües de Barcelona. Compiled by the authors, 2014.

Figure 13. Fall in water billed in the municipalities served by Aigües de Barcelona



Source: Municipal Map of Catalonia, ICC. Administrative limits of Barcelona,

From all of this it can be seen that it is easier to reduce the least essential outdoor uses, but also that there is a difficulty in reducing consumption to any significant extent, as it is already very low in the majority of municipalities. However, the decrease in water consumption, in percentage terms, is also significant in the high-density, low-income municipalities.

It is also very interesting to compare how water billing varies year on year. As previously mentioned, the most important reductions by far occurred between 2007 and 2008 and can, with a degree of certainty, be attributed to one of the worst droughts in decades. In Table 11 we can observe how the municipalities with higher consumptions, such as Begues, are also the ones that have reduced their water demand the most between 2007 and 2008.

However, other municipalities, with more moderate consumption and lower incomes also experience significant drops in consumption. Moreover, the decrease in 2012 and 2013 observed in some municipalities with extensive urban development could be attributed to the effects of the rising water rate and especially the creation of a fourth tranche that may have affected consumption for outdoor uses.

Table 11. Year-on-year evolution (%) of total water billed in the municipalities served by Aigües de Barcelona

	Var. 2007-08 (drought)	Var. 2008-2009	Var. 2009-2010	Var. 2010-2011	Var. 2011-2012	Var. 2012-2013	Var. 2009-2013 (post-drought)	Total evolution 2007-2013 (%)
Barcelona	-6.4	-1.1	-0.2	0.0	-0.9	-1.9	-2.98	-10.12
L'Hospitalet de Llobr.	-6.7	-1.5	-2.7	-1.3	-2.2	-1.3	-7.27	-14.83
Cornellà de Llobr.	-10.3	0.8	-3.0	0.8	-1.5	-0.1	-3.85	-13.03
Gavà	-7.5	-0.9	-0.2	-2.2	0.8	-5.3	-6.98	-14.70
Sant Boi de Llobr.	-6.2	-0.9	-3.1	-2.9	1.0	-0.6	-5.59	-12.26
Santa. Coloma de Cerv.	-19.6	-2.7	1.1	2.7	-2.6	-2.2	-1.03	-22.56
Viladecans	-2.1	-0.9	-3.8	1.0	-0.4	-1.1	-4.32	-7.14
Castelldefels	-8.2	1.6	-0.7	-1.7	2.0	-3.5	-3.91	-10.40
Torrelles de Llobr.	-12.9	5.8	-0.9	-2.5	1.5	-2.5	-4.39	-11.88
Esplugues de Llobr.	-7.8	0.9	-3.4	-0.3	-1.5	2.2	-3.06	-9.82
Sant Feliu de Llobr.	-9.5	-1.8	-1.1	-1.5	0.2	0.7	-1.61	-12.61
Sant Joan Despí	-7.6	2.0	1.2	-0.8	-3.7	0.2	-3.17	-8.74
Sant Just Desvern	-13.1	2.6	-2.6	-6.2	-0.9	1.2	-8.41	-18.37
Badalona	-4.6	-1.8	-2.0	-1.4	-1.2	-2.0	-6.48	-12.38
Cerdanyola del Vallès	-10.1	3.3	0.8	-0.8	1.9	-6.2	-4.38	-11.29
Montcada i Reixac	-4.0	-4.1	-1.4	-3.2	-3.2	-1.8	-9.25	-16.46
Montgat	-3.4	0.0	-1.6	-1.7	1.6	2.5	0.64	-2.79
Sant Adrià de Besòs	-2.1	-1.5	-5.7	-2.7	-2.0	2.5	-7.75	-11.06
Santa Coloma de Gram.	-5.5	-5.9	-4.9	-0.8	-1.9	0.0	-7.49	-17.79
Begues	-19.8	11.2	-5.6	-0.4	-4.3	-8.6	-17.76	-26.59
El Papiol	-2.8	-4.0	-11.0	-5.5	5.5	-7.5	-17.94	-23.41
Pallejà	-13.3	8.3	-0.4	-7.2	6.5	-8.6	-10.10	-15.60
Sant Climent de Llobr.	-4.0	2.2	-8.2	2.7	-0.4	-3.2	-9.07	-10.87
Total	**-6.6**	**-1.0**	**-1.1**	**-0.5**	**-0.9**	**-1.8**	**-4.19**	**-11.37**

Source: Aigües de Barcelona. Compiled by the authors, 2014.

3.2 Evolution of domestic consumption in the municipalities of the metropolitan area of Barcelona served by Aigües de Barcelona (2007-2013)

Table 12 displays the evolution of the population of the municipalities of the metropolitan area of Barcelona served by Aigües de Barcelona between 2007 and 2013 (in percentage terms) and the evolution of domestic water consumption billed in absolute terms and in litres per capita per day (see also Figure 14). On the one hand, we can see how the majority of the municipalities are growing in population terms, but, on the other hand, we can also see how domestic consumption is decreasing in absolute terms in most of these municipalities.

With these population figures, it has been possible to calculate the litres per capita per day of domestic water consumption (from now LPCD). In the third column of Table 12, we see that the percentage reduction in LPCD is greater than the absolute reduction in domestic consumption, since the population has increased over the period studied.

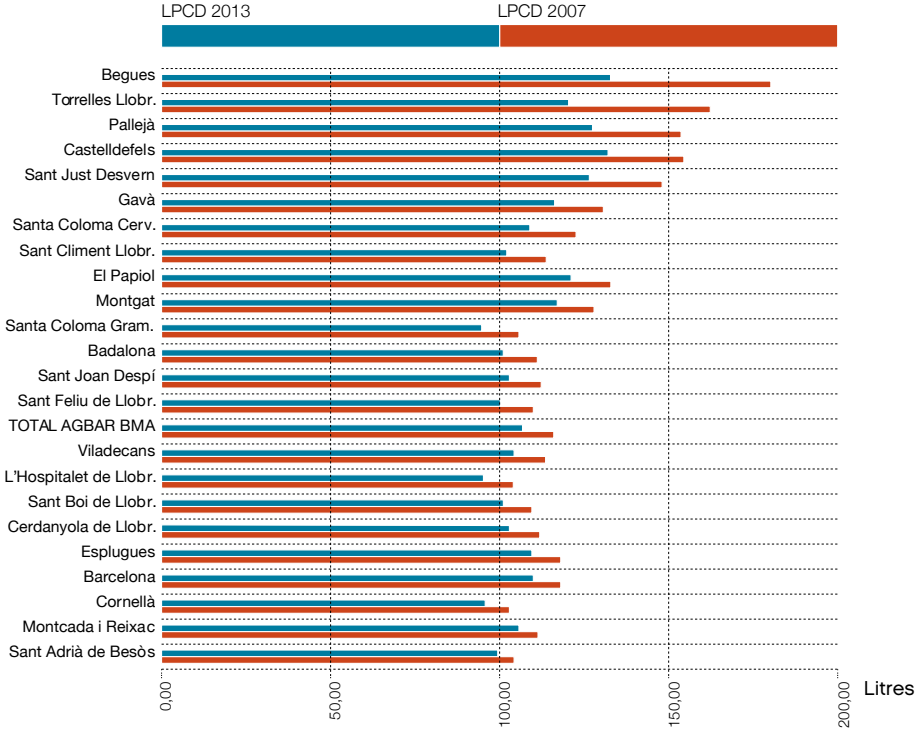
Table 12. Population evolution (%), evolution of household water billed and domestic consumption per capita (2007-2013)

	Population evolution (%)	Evolution household water billed (%)	Evolution LPCD (%)
Barcelona	1.05	-5.84	-6.82
L'Hospitalet de Llobregat	0.88	-7.96	-8.76
Cornellà de Llobregat	2.62	-4.84	-7.27
Gavà	3.80	-7.65	-11.03
Sant Boi de Llobregat	3.32	-4.95	-8.00
Sta. Coloma de Cerv.	7.35	-4.72	-11.25
Viladecans	6.04	-2.50	-8.05
Castelldefels	6.99	-8.59	-14.56
Torrelles de Llobregat	16.12	-13.69	-25.67
Esplugues de Llobregat	0.82	-6.22	-6.99
Sant Feliu de Llobregat	3.54	-5.58	-8.80
Sant Joan Despí	3.60	-5.32	-8.61
Sant Just Desvern	9.54	-6.30	-14.46
Badalona	1.62	-7.68	-9.15
Cerdanyola del Vallès	-0.20	-8.06	-7.87

	Population evolution (%)	Evolution household water billed (%)	Evolution LPCD (%)
Montcada i Reixac	8.57	2.57	-5.53
Montgat	13.06	3.30	-8.63
Sant Adrià de Besòs	6.38	1.41	-4.67
Sta. Coloma de Gram.	2.80	-7.88	-10.39
Begues	11.73	-17.65	-26.30
El Papiol	6.88	-2.50	-8.77
Pallejà	3.60	-14.07	-17.05
Sant Climent de Llobregat	7.96	-3.22	-10.36
Total Agbar BCN metropolitan area	**1.90**	**-6.14**	**-7.89**

Source: Aigües de Barcelona and the National Statistics Institute (INE). Compiled by the authors, 2014.

Figure 14. Domestic consumption per capita per day (LPCD) in 2007 and 2013



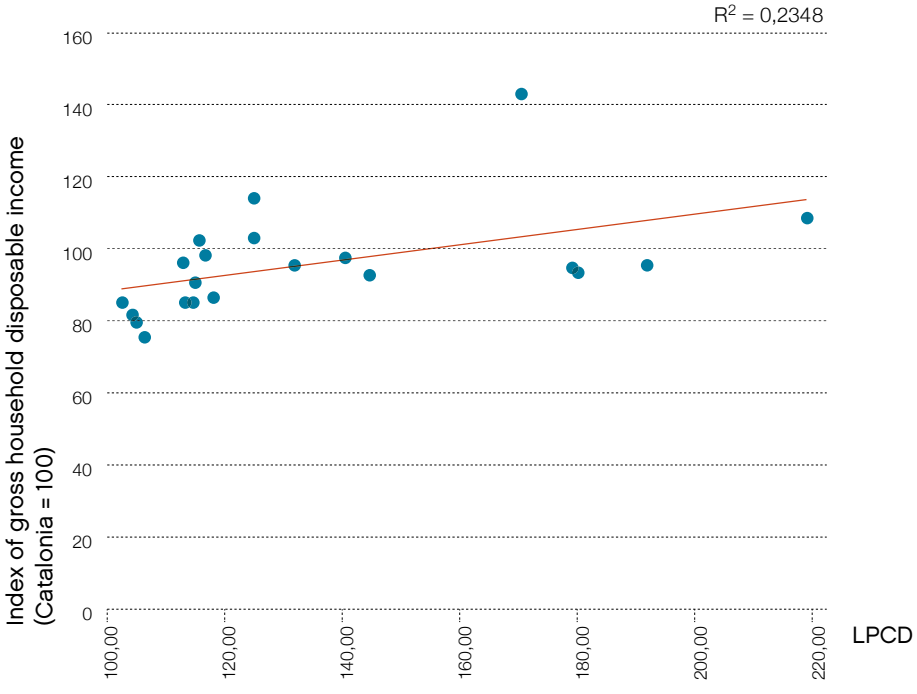
Source: Aigües de Barcelona and the National Statistics Institute (INE). Compiled by the authors, 2014.

Figure 14 displays LPCD figures for 2007 and 2013. As already mentioned in the previous paragraph, Begues, the municipality with one of the highest domestic consumptions per capita of the municipalities served by Aigües de Barcelona customers, is also the one with the largest reduction, in percentage terms, between 2007 and 2013. This chart gives an idea of the spatial differentiation in the consumption of water among the different municipalities served by Aigües de Barcelona, as well as the spatial differences in the reduction in consumption between 2007 and 2013. Thus we can see that, in 2007, between the municipality with the highest rate of consumption, Begues (177.95), and the lowest, Cornellà de Llobregat (101.54), there was a difference of 76.41 litres; in other words, the consumption per capita per day in Cornellà was almost 43% lower than Begues. However, in 2013, it appears that the difference between Begues (131.15) and the municipality with a lower rate, which is no longer Cornellà (94.16), but rather Santa Coloma de Gramenet (93.32), has fallen to 37.83 litres, i.e. the difference is now 28.84%. This may indicate that in recent years there has been a tendency towards a certain homogenisation in consumption, especially due to the larger decrease experienced by outdoor uses, even if there continue to be significant differences between municipalities.

To better understand these changes at the metropolitan level and in the city of Barcelona, we must examine them in the light of the evolution of different socio-demographic and economic variables.

It can also be seen that there is a certain relation between income and consumption by the municipalities in the metropolitan area of Barcelona served by Aigües de Barcelona (Figure 15). However, the limited data available for this variable and for consumption per capita between 2008 and 2012 does not allow us to make a calculation for any year other than 2008.

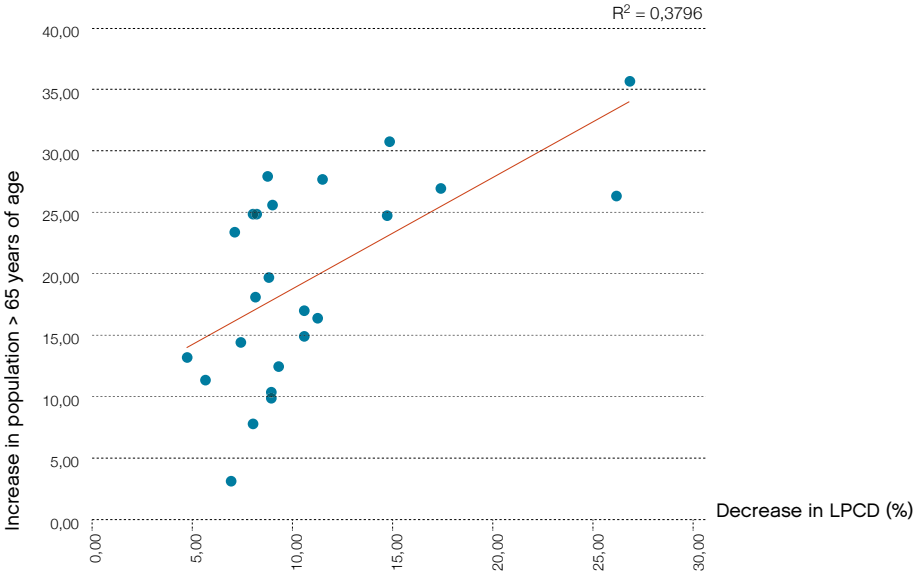
Figure15. Ratio between gross household disposable income and LPCD (2008)



Source: Aigües de Barcelona and the Statistical Institute of Catalonia (Idescat). Compiled by the authors, 2014.

If we add other socio-demographic variables related to the foreign population and the ageing of the population (INE 2007 and 2013 continuous census data) we also obtain interesting results. All the municipalities show an increase in the total population over 65 years of age between 2007 and 2013, with increases in some cases greater than 25%. At the aggregate metropolitan level, the increase in the over-65 population in 2013 compared to 2007 was 7.87%. As you can see in Figure 16, a remarkable correlation can be observed (R^2 = 0.379) between the increase in the population over 65 years of age and decreased water consumption.

Figure 16. Correlation between decreased LPCD (%) and increase in the over-65 population (%)

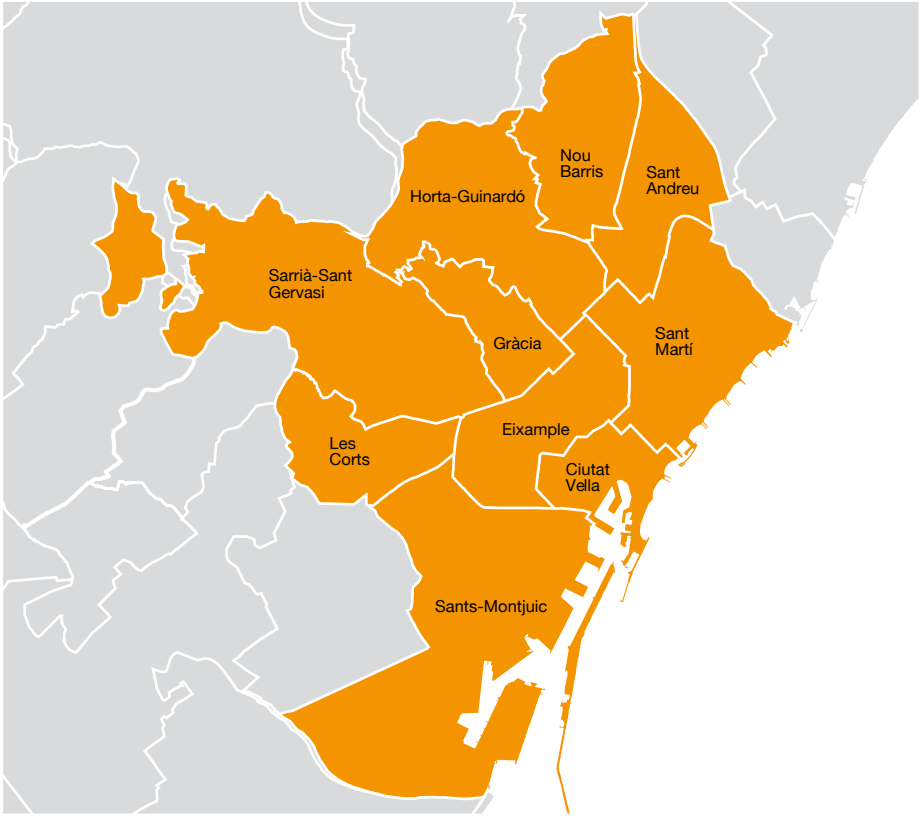


Source: Aigües de Barcelona and the National Statistics Institute (INE). Compiled by the authors, 2014.

Moreover, the foreign population increased by 15.39% between 2007 and 2013 in the municipalities served by Aigües de Barcelona. However, the differences between municipalities are relevant, thus there are municipalities where the total number of foreigners has decreased and others where it has increased very significantly, by more than 30%. However, these data do not take into account the evolution of the total population and the evolution of the weighting of these groups in the general population in 2007 and 2013. No significant correlations between this variable and decreased water consumption were detected.

Evolution of domestic consumption in the districts of Barcelona

Figure 17. Municipal districts of Barcelona



Source: Municipal Map of Catalonia, ICC. Administrative limits of Barcelona, Barcelona City Council.

As regards the evolution of water consumption in the 10 municipal districts in Barcelona between 2007 and 2012, table 13 shows how this has decreased in all districts, both in absolute terms and in relative terms. The greatest decrease corresponds to the district of Les Corts, a middle -to upper-class district, but which also includes the district of Pedralbes, Barcelona's wealthiest district, where houses with gardens and swimming pools abound.

Table 13. Variation (%) in domestic water billed by district (2007-2012)

	2007-2012
Ciutat Vella	-4.66
Eixample	-6.45
Sants-Montjuïc	-5.50
Les Corts	-7.35
Sarrià-Sant Gervasi	-6.45
Gràcia	-4.48
Horta-Guinardó	-6.10
Nou Barris	-6.68
Sant Andreu	-5.06
Sant Martí	-2.44

Source: Aigües de Barcelona and the Department of Statistics, Barcelona City Council. Compiled by the authors, 2014.

Table 14 shows the annual evolution in absolute terms of the LPCD by district. However, it is also interesting to note the percentage change in the LPCD with respect to the previous year, as this allows us to clearly ascertain when the largest decreases occur and whether they occur differentially by district. Thus, Table 15 indicates that the largest decreases for all districts were recorded between 2007 and 2008, coinciding with the peak of the worst drought in decades.

Furthermore, as happened with the municipalities in the metropolitan area of Barcelona served by Aigües de Barcelona as a whole, the greatest decreases correspond to the districts with the highest consumption in 2007, that is, Les Corts and Sarrià-Sant Gervasi, where outdoor uses linked to low-density housing is more common.

However, it is clear that in recent years the decreases (in any case more moderate than in the period 2007-2008) were slightly more intense in the relatively low-income districts such as Sants-Montjuïc, Nou Barris and Sant Andreu.

Table 14. Evolution (in litres) of LPCD by district (2007-2012)

	2007	2008	2009	2010	2011	2012
Ciutat Vella	104.02	101.82	103.64	106.30	106.96	105.90
Eixample	129.16	122.98	120.86	121.91	121.17	119.30
Sants-Montjuïc	112.07	107.30	105.15	104.68	104.49	102.69
Les Corts	131.59	124.28	123.89	122.19	122.42	120.74
Sarrià-Sant Gervasi	148.95	139.89	138.68	137.84	136.94	135.22
Gràcia	118.98	113.23	111.97	111.52	112.79	112.03
Horta-Guinardó	107.95	103.34	101.61	101.28	101.03	101.03
Nou Barris	100.18	95.46	95.13	94.27	93.70	92.12
Sant Andreu	107.04	101.95	101.28	100.54	99.75	98.66
Sant Martí	107.55	103.23	103.40	102.38	101.81	100.51

Source: Aigües de Barcelona and the Department of Statistics, Barcelona City Council. Compiled by the authors, 2014.

Table 15. Evolution (%) of per capita consumption (LPCD) by district, compared to the previous year

	2008	2009	2010	2011	2012
Ciutat Vella	-2.1	1.8	2.6	0.6	-1.0
Eixample	-4.8	-1.7	0.9	-0.6	-1.5
Sants-Montjuïc	-4.3	-2.0	-0.4	-0.2	-1.7
Les Corts	-5.6	-0.3	-1.4	0.2	-1.4
Sarrià-Sant Gervasi	-6.1	-0.9	-0.6	-0.7	-1.3
Gràcia	-4.8	-1.1	-0.4	1.1	-0.7
Horta-Guinardó	-4.3	-1.7	-0.3	-0.2	0.0
Nou Barris	-4.7	-0.3	-0.9	-0.6	-1.7
Sant Andreu	-4.8	-0.7	-0.7	-0.8	-1.1
Sant Martí	-4.0	0.2	-1.0	-0.6	-1.3

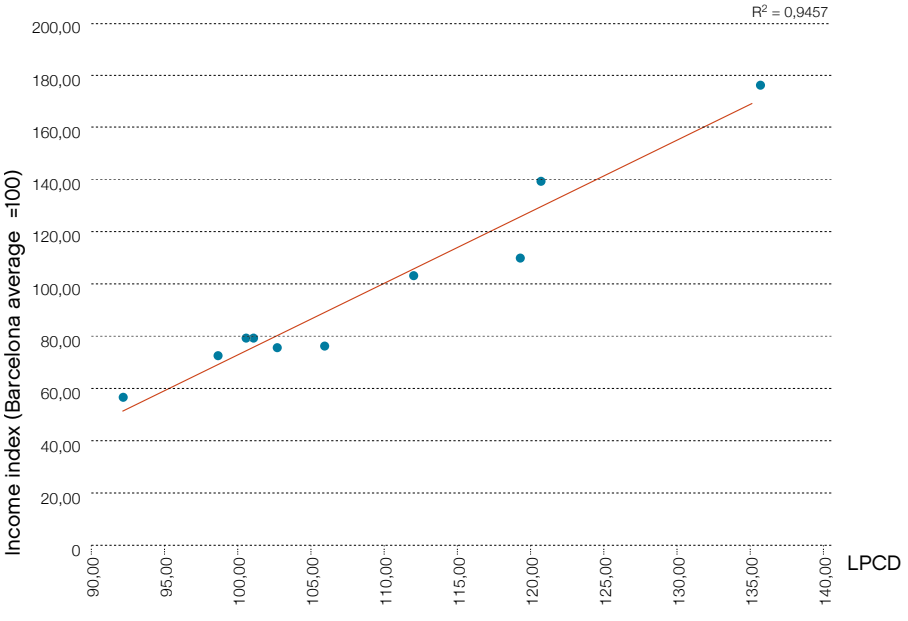
Source: Aigües de Barcelona and the Department of Statistics, Barcelona City Council. Compiled by the authors, 2014.

As we have already seen, the decreases in per capita consumption in an urban setting, traditionally characterised by relatively low figures, make all the municipalities in the metropolitan area of Barcelona served by Aigües de Barcelona and, in particular, certain municipalities on the immediate periphery of Barcelona, among the urban areas in the developed world with the lowest levels of water consumption. In

Barcelona, two districts, Sant Andreu (98.6 LPCD) and Nou Barris (92.1 LPCD), have total values below the limit of 100 litres/person/day recommended by the World Health Organization and a further three districts barely exceed this threshold. Besides having low consumption when compared to Western standards, it is also evident that there is a clear spatial segregation in this consumption. Thus, between the district with the highest consumption in 2013 (Sarrià-Sant Gervasi) and the lowest (Nou Barris), a difference of more than 43 litres can be seen; in other words, the per capita consumption in Nou Barris is almost 32% lower than in Sarrià-Sant Gervasi. However, if these data are compared with those of 2007, we can see that the difference in absolute terms is lower. In 2007, the difference between Sarrià-Sant Gervasi (148.95 LPCD) and Nou Barris (100.18 LPCD) was 48.77 litres. Nonetheless, the consumption per capita in Nou Barris was 32.74% lower than in Sarrià-Sant Gervasi (very similar to the 2013 figure).

Below we present a brief set of conclusions at Barcelona district level on the relationship between water consumption and other economic and demographic variables.

Figure 18. Correlation between income and LPCD in Barcelona districts (2012)



Source: Aigües de Barcelona and the Department of Statistics, Barcelona City Council. Compiled by the authors, 2014.

Firstly, income shows a clear correlation with drinking water but not with unemployment, probably due to distortions such as the weighting of the informal economy, registry problems, etc. This is consistent with most studies of this economic variable. Thus, income not only affects the ability to pay for water, but also the type of housing, the availability of household appliances, consumer habits, etc. Table 16 and Figure 18 show how the correlations between income and water consumption are very high for all the years considered, taking into account all the districts, with R^2 higher than 0.9.

Table 16. Correlations (R^2) between income and LPCD by year (taking into account the 10 districts)

2008	0.9415
2009	0.9616
2010	0.9369
2011	0.9439
2012	0.9457

Source: Compiled by the authors, 2014.

On the one hand, when the correlation between income and water consumption for the various municipal districts are calculated, taking into account all the years, and with the limitation of only having a short series of data, we see that these correlations are particularly high in those districts with low incomes and low consumption (Table 17). There is, therefore, an important correlation in the poorest districts between decreases in the income index and decreases in water consumption. On the other hand, if we look at the values in Table 18, we can see that in Barcelona inequalities in terms of income increased significantly with the economic crisis that began in 2008. Therefore, while the districts with the highest incomes have not experienced a change in their income index, or have even seen it increase, all of the districts with lower incomes, with the exception of Ciutat Vella, have seen their income index fall. It could be inferred that the lower income districts may even be reducing their most basic water consumption needs due to the crisis.

Table 17. Correlations (R^2) between income and LPCD by district (taking into account the years 2007-2012)

Ciutat Vella	0.8701
Eixample	0.6870
Sants-Montjuïc	0.7472
Les Corts	0.0741
Sarrià-Sant Gervasi	0.0788
Gràcia	0.2465
Horta-Guinardó	0.9396
Nou Barris	0.8845
Sant Andreu	0.8186
Sant Martí	0.6656

Source: Aigües de Barcelona. Compiled by the authors, 2014.

Table 18. Evolution of disposable household income index (Barcelona Index = 100) (no data for 2012)

	2008	**2009**	**2010**	**2011**
Ciutat Vella	71.10	74.20	75.20	77.00
Eixample	114.90	114.50	114.40	112.00
Sants-Montjuïc	80.70	78.40	76.10	75.10
Les Corts	140.00	138.40	140.70	141.40
Sarrià-Sant Gervasi	177.60	182.60	186.20	178.90
Gràcia	103.20	101.90	102.50	105.80
Horta-Guinardó	86.70	82.90	80.70	80.30
Nou Barris	70.10	65.70	63.20	61.60
Sant Andreu	82.50	78.50	74.50	74.10
Sant Martí	87.50	83.70	81.50	81.70

Source: Department of Statistics, Barcelona City Council. Compiled by the authors, 2014.

In terms of other socio-demographic variables, we observe some interesting relationships, which, although they do not prove causality, do highlight trends that have also been observed in other studies. For example, if we compare the percentage variation in foreign-born citizens with the variation in water consumption (LPCD) in percentage terms, it becomes evident that there is a certain inverse correlation (R^2 = 0.3518) between the two variables. Worthy of note is the relationship that exists in various age-related variables. For example, a high inverse correlation is seen between the evolution of the ageing population index, which

measures the ratio of persons over 65 years of age to those under 14 years of age, and the evolution of the LPCD by district (R^2 = 0.6578).

We should once again highlight that all of the statistical correlations presented do not prove causality, but rather only indicate a relationship; furthermore, we wish to point out that the number of cases for the study of Barcelona is very small (10 cases). Thus, these correlations only indicate trends, and the correlation coefficients presented (R^2) must be interpreted qualitatively. However, we also wish to clarify that such correlations have been developed based on previous results from other studies in Barcelona, as well as results that have been presented in the international scientific literature.

The effects of the economic crisis, especially among the working classes, combined with sharp price increases and water taxes, probably explain a significant part of the decreases in water consumption. Another aspect that should be highlighted in explaining the decreases in water consumption is that relating to water-saving and -conservation campaigns. In this case, it would appear that the repetition and insistence of public service announcements in the media associated with droughts have been highly effective, as well as the implementation of proactive measures, such as the free distribution of water-saving kits during the drought of 2008 in Barcelona, which were remarkably successful.

The supply of these devices to citizens raised an interesting paradox that highlights the degree of misinformation regarding these water-saving tools. Thus, in some cases, users attempted to install flow regulators on taps in homes which, since they were newly built housing, already had these devices. Moreover, the presence of more efficient household appliances (washing machines, dishwashers, etc.) has also undoubtedly contributed to the decline in consumption.

Evolution of prices and taxes in the municipalities in the metropolitan area of Barcelona served by Aigües de Barcelona

Throughout this section we have emphasized the role that prices and taxes may have played in the decline in domestic water consumption. In fact, the international literature urges a separation of economic factors on the one hand and administrative regulations on the other (e.g. restricting certain uses by law), as the main factors leading to the decrease in water consumption.

With regard to economic factors, in the municipalities in the metropolitan area of Barcelona served by Aigües de Barcelona, the water bill includes a

rate for supplying the water charged by the supplying company, plus the so-called 'water rate' applied by the Catalan Water Agency (ACA), the public body responsible for resource planning and management in the so-called 'inland basins of Catalonia'. Both items are exclusive of value added tax (VAT) which in Spain, in the case of water, has risen from 7% in 2007 to 10% in 2013.

The pricing structure applied to the households in the municipalities in the metropolitan area of Barcelona served by Aigües de Barcelona is divided into a fixed part and a variable part. The fixed part or service fee varies depending on the contracted nominal flow. The variable part follows a model which charges by consumption tranche, along an increasing price scale. The aim of this model is to conserve the resource, such that certain levels of consumption are penalised with the application of higher prices. This model is applied in Spain generally and in countries with limited resources, while in countries with abundant water resources in Northern and Central Europe the prevailing rate model is that of a flat rate with a single price per m^3. In the municipalities in the metropolitan area of Barcelona served by Aigües de Barcelona, in the period considered, the variable part includes three consumption tranches: tranche 1 (for consumption between 0-6 m^3/month), with a discount price to ensure access for essential applications; tranche 2 (for consumption between 7-12 m^3/month); and tranche 3 (for consumption greater than 12 m^3/month). For the purposes of fairness, the limits of the tranches are extended depending on the number of people living in the same household.

During the period studied, the so-called water rate has not only significantly increased, but rather it has also seen its structure modified with the creation of a fourth consumption tranche subject to a highly progressive scale (the price of the fourth tranche is 9 times higher than the first consumption tranche).

Table 19 shows the modifications introduced between 2007 and 2013. It is noteworthy that 2011 was the year in which the social tax was created, establishing a fee for the first tranche without increases for holders of contracts with consumptions equal to or lower than the basic allowance, and provided they met one of the two situations provided for in Article 40 of the Law on Government of Catalonia budgets: a) contract holders 60 years of age or older who are considered pensioners due to retirement, disability or the death of a spouse; and b) those belonging to a family unit in which all of the members are unemployed.

Table 19. Changes in the structure of the water rate 2011-2012

	From 2007 to 30 September 2011	From 1 October to 24 March 2012	From 24 March 2012
Tranche 1	0-10 m^3/month	0-9 m^3/month	
Tranche 2	10-18 m^3/month	9-15 m^3/month	
Tranche 3	> 18 m^3/month	> 15 m^3/month	15-18 m^3/month
Tranche 4	—		More than 18 m3/month
Social tax	—	Consumption below basic allowance and meeting requirement	

Source: Aigües de Barcelona. Compiled by the authors, 2014.

3.3 Evolution of non-domestic consumption in the municipalities in the metropolitan area of Barcelona served by Aigües de Barcelona (2007-2013)

Of the three major categories in the field of non-domestic water uses, industrial uses have seen the sharpest decline, decreasing by around 20% in the period 2007-2012 (see Table 20). The economic crisis has led to the closure or reduction in activity of many companies and, furthermore, the increased incidence of environmental regulations no doubt explains part of this decline, along with the introduction of more efficient production processes in the use of resources. However, it should be noted that this reduction relates only to the public water network, without considering alternative sources of supply. In this sense, many companies in Zona Franca and the Llobregat Delta have their own wells and therefore do not use the water network. Therefore, the decline in industrial consumption may be less than that indicated in the data from suppliers.

Table 20. Evolution (%) of water consumption in different sub-sectors for all of the municipalities served by Aigües de Barcelona as a whole. Note: The period considered is 2007-2012 (not 2013) because this is the last year for which disaggregated data for the commercial, industrial and municipal sectors were available.

Commercial	Industrial	Municipal	Domestic
-12.61	-19.49	-18.63	-5.72

Source: Aigües de Barcelona. Compiled by the authors, 2014.

Municipal uses have also seen a significant decline in water consumption, similar to the industrial sector, although, in general, these users pay a relatively low price for the resource. In this case, it is interesting to compare the drought period from 2007-2008 with the economic crisis that began

almost immediately after. During the drought, the municipalities that had developed alternative resources, mainly local underground aquifers, were better able to meet their water needs than those whose resources came exclusively from the public network, since the latter were subject to restrictions by the decrees on drought. When water levels recovered after the drought, the municipalities opted to return to using water from the public network, which is cheaper than the 'alternatives', even for uses such as street cleaning or irrigation of public spaces. In the next section, which analyses the behaviour of the 50 largest water consumers in the municipalities in the metropolitan area of Barcelona served by Aigües de Barcelona, which includes several municipalities, we explain their behaviour in greater detail.

As regards use in tourism, which is included in the category of commercial and industrial applications, this has acquired an increasingly important role in the metropolitan economy. During the drought of 2007-2008, the possibility of restrictions caused many Barcelona hotels to introduce saving measures. According to studies on water consumption in the Barcelona hotel industry, it has been concluded that the periods of drought led to the adoption of water-saving measures. These saving measures are intensified when the droughts are severe enough to endanger the supply, as almost occurred in 2008. During this drought, there was a fear of devastating consequences for the city's tourism image due to the water restrictions. The study also showed that the higher-rated hotels are, in principle, those most likely to promote water-saving and conservation policies at their facilities, as they are the ones with the highest consumption.

As for sports facilities, it should be highlighted that these replaced their toilets and urinals with more efficient devices. Similar saving measures have also been implemented to reduce consumption in green areas. Moreover, virtually all the municipal swimming pools have already installed a closed water cycle, without the need to replenish the water.

4. SURVEY OF MAJOR CONSUMERS

4.1 Sources and method of analysis

As already indicated in the introduction, the purpose of the major consumer survey was to provide information on their uses and consumption habits and any recent changes in the latter, particularly those that might explain the decline in water consumption between 2007 and 2013. The survey contained a total of 50 questions divided into the following sections and subsections:

1. Basic information regarding the organisation (government agency or company)

2. Approximate volume of water allocated to the various uses within the organisation

3. Source of the water used

4. Characteristics and trends in water consumption in different usage areas at the organisation (applicable areas depending on the activity)

5. Water leaks and loss

6. Overall trends in water consumption within the organisation (increase, decrease)

7. Changes in water management within the organisation and reasons for these changes

8. Environmental certificates

9. Other water-saving measures

10. Observations

The survey, therefore, contains a collection of information that is highly relevant to explain recent trends in water use and habits for a specific sector of urban consumption hitherto little studied in Spain. The survey focuses on non-domestic users of the municipalities served by Aigües de Barcelona in the city of Alicante. From among these users, it was decided to select a sample comprising the largest 50 water users (by volume) at Aigües de Barcelona and the top 25 water users in the city of Alicante.

4.2. Analysis and presentation of the results of the surveys on major consumers in Alicante

The sector of major water consumers has taken on significant weight among urban uses of water in the city of Alicante, where we find that around 35 customers use more than 20,000 m^3/year, with a consumption of 3,121,159 m^3, which in 2013 represented more than 14% of the total billed drinking water volume. The financial and economic crisis that erupted in Spain in 2007 has had serious consequences for the manufacturing sector in the city of Alicante.

Among the largest official registered customers, the Alicante City Council occupies a very prominent place. Also significant is the consumption of other official bodies such as the Government of Valencia, the Port Authority, the University of Alicante and Alicante Prison.

In the industrial sector, the biggest customer is an industrial company dedicated to food production. With a water billing of between 50,000 and 80,000 m^3/year, there are 6 other major consumers, including 3 industrial companies engaged in the production of cement, rolled aluminium and the packaging of olives, respectively, as well as a large retail complex, a hotel and another official agency. However, the segment with a total water billing of between 20,000 to 30,000 m^3/year is the most numerous segment, with more than 20 registered customers including several hotels, hospitals, shopping centres, industries, residential communities and sports facilities.

General consumption trends among the major consumers of drinking water in the city of Alicante (2007-2013)

Despite the wide-ranging factors influencing the evolution of water consumption among registered customers who are major consumers in Alicante, two primary trends can be identified from the set of water billing data that has been analysed:

1. Moderate to strong increase in the volume of water billed. This group includes around 12 major consumers, which during the indicated period from 2007 to 2013 have seen a moderate or even a sharp rise in their consumption. Within 5 of these registered customers, water consumption has increased by more than 50%, and in another the growth exceeded 109%.

2. Mild or moderate to severe reduction in consumption. This trend affects more than 50% of the major registered customers in Alicante, although with large differences between them, making it necessary to separate them into two groups:

a) Firstly, a group of major registered customers which have experienced mild to moderate relative declines in their water billing, always less than 12%, and even in some cases less than 4%. This group includes two important companies in the supermarkets and department stores sector, which have experienced a reduction in their water billing of less than 2% during the period from 2007-2013.

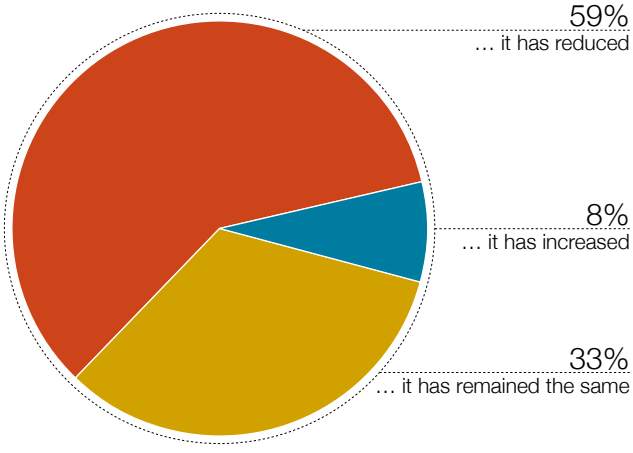
b) Secondly, we find a group containing major consumers that have experienced a sharp reduction in their consumption, with relative decreases

greater than 25%, and in some cases 50%. The highest figures are found at four major industrial businesses in the food industry and the rolled aluminium manufacturing industry, which have suffered a sharp decline in their manufacturing activity since 2007. This decrease is linked to the drop in sales caused by the economic crisis, but also to the effects of business strategies aiming to relocate manufacturing to other existing plants in Spain.

Causes of the water consumption trends at major consumers

The results of the surveys of major consumers in the city of Alicante reveal the following trends:

Figure 19. Consumption trends in the organisations surveyed



Source: Interviews 'Management of water consumption by non-domestic sector users in the city of Alicante', 2014.

The estimated average percentage reduction in water expenditure within companies that have reduced their consumption is 18.86%, with values that range from 10% to 30%.

Regarding the motives that may have contributed to this reduction, relevant factors are the adoption of more efficient systems, the effect of the crisis on the manufacturing system or the water rate. Regarding the first option, 58% replied that it was due to the installation of more efficient appliances (dual flush toilets, new taps, etc.).

Also notable are the answers to the question whether the decrease is due to the reduced activity of the company. Twenty-five per cent answered with

a 'yes', and 33% with a 'no', with the rest responding 'do not know/no answer', i.e. there is no clear relationship between the economic decline and decreased consumption. This is largely due to the wide range of sectors included under the heading 'major consumers': ranging from health and educational facilities, through sports and logistics facilities, to companies performing manufacturing activities in the strictest sense.

When these registered customers were asked whether the reasons for the reduction in their water consumption were related to greater environmental awareness in water-saving, 33% responded that this was indeed a factor, with 25% replying that it was not; however, the reply 'do not know/no answer' was once again the most frequent response.

No link was detected between the price of the water and the fall in consumption. None of the companies surveyed replied that the decline in demand was due to the rising price of water. Of the answers obtained, 58% put forward non-economic reasons, while the rest responded 'do not know/no answer'.

To understand the causes of the decline in water consumption among registered customers that are major consumers, it is necessary to analyse the responses relating to changes in spending habits in the area of water. A high percentage of respondents, 83%, said that in the last five years they had made modifications to water management at their organisation in order to reduce consumption. The reasons given for this stance were mostly economic, with economic factors being the explanation given by 60% of those who responded affirmatively, while the remaining 40% were distributed equally between environmental awareness and having more efficient technologies.

The number of major consumers who have environmental certification (ISO 14000 and ISO 14001) is small. This result confirms the importance that economic factors have in reducing water consumption, compared with the adoption of technologies that minimise such consumption. Positive responses were received mainly from companies that have applied for this certification and wish to accredit the fact that they are following environmental best practices, for reasons of public image in the eyes of their users or public opinion, given the strong environmental impact of some of their activities.

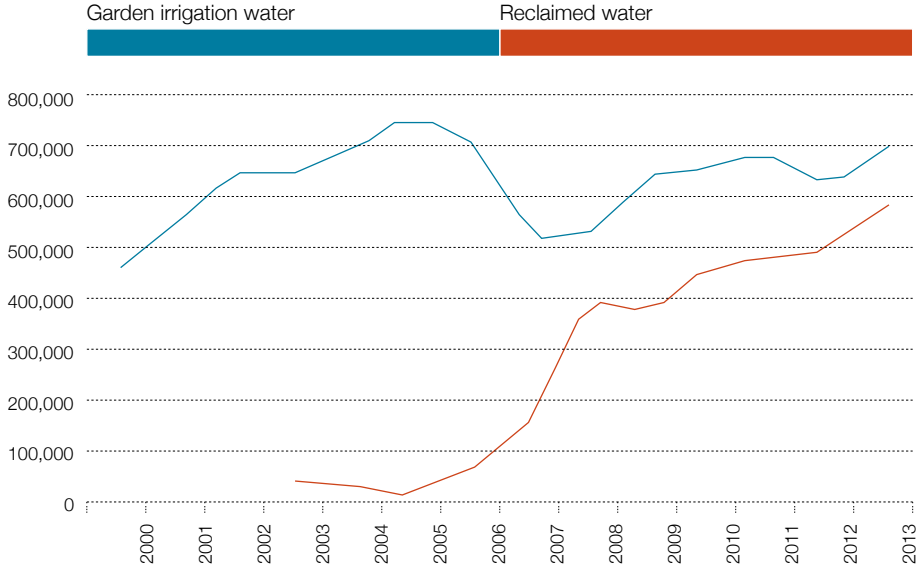
The Alicante City Council

The Alicante City Council is by far the largest user of water in the city, with a water billing volume in 2013 of 1,250,701 m^3. This is in addition to the use of reclaimed water, around 587,357 m^3, and with 40,000 m^3 being provided by

several water wells that collect resources from local aquifers, intended for washing and cleaning the streets.

Regarding water consumption in gardens, public parks and green areas, the survey results show that initiatives have been launched to replace traditional irrigation systems with more efficient systems, and to promote the use of reclaimed water. If we examine the distribution of the different irrigation systems in parks and gardens as a percentage, in most cases, which is 70%, a drip is used, while 20% use sprinklers and the remaining 10% use a hose.

Figure 20. Evolution of irrigation water and reused water in the city of Alicante



Source: AMAEM, 2014.

Regarding water consumption at municipal sports facilities which require water, in the past five years the surface area of their playing fields has reduced and been replaced with artificial turf.

A specific section has focused on public swimming pools. In the last five years, closed-circuit water purifiers have been installed. In addition, generally and compared to previous years, it has been confirmed that the maintenance of these components requires less water, which have produced significant savings.

Ornamental elements requiring the use of water, such as fountains, ponds or water facilities, have also been analysed. In the last five years, systems have

been installed to improve the efficiency of water use in these components and the frequency of water renewal in fountains or ponds has been reduced.

As regards the washing and cleaning of streets, water consumption has fallen. It has also been pointed out that, at times, water for street cleaning is obtained from sources other than the public network, mainly groundwater from local aquifers. Overall, 40% of the water supply for this activity comes from the public network and the remaining 60% from groundwater infrastructures and groundwater catchment wells.

The main urban function that characterises and defines Alicante as a city is that of a city of services. Consequently, the City Council has a large number of municipal offices. In this type of use, the demand for sanitation and hygiene services have assumed primary importance. The survey carried out with the technical departments confirms that in the past five years water-saving systems have been incorporated at municipal facilities, including tap timers, electronic taps, dual flush toilets or efficient lavatories.

The section focusing on the management and conservation of the water resource in public applications received responses indicating that no municipal regulations related to water conservation exist. However, it has been noted that in the last five years institutional information campaigns have been promoted and training given to municipal workers encouraging water conservation, for example, environmental education campaigns. It should also be noted that in recent years no measure has been introduced that would make it possible to ensure better control and monitoring of the use of water in public applications.

4.3 Analysis and presentation of the results of the surveys of Aigües de Barcelona 's major consumers in the municipalities within the metropolitan area of Barcelona

In this section we present the main results of the survey performed on major consumers of water in the non-domestic segment in the municipalities in the metropolitan area of Barcelona served by Aigües de Barcelona during the months of January and February 2014. They have been divided into two main groups: a) city councils, which are the largest water users in the non-domestic sphere; b) and the industrial and commercial sectors..

Water consumption by city councils

Most municipal water use is aimed at the irrigation of landscaped surfaces in parks and green areas. Specifically, over 75% of the city councils

surveyed stated that irrigation accounts for 50% or more of their total water consumption. More than half of the municipalities that responded to the survey state that water use in buildings accounts for about 20% of the water used, mainly in toilets. As regards municipal swimming pools, these account for about 10% of the total consumption in 50% of cases. Street cleaning accounts for 10% or less of the water used in more than 80% of the cases.

Questions relating to the source of the water lead to a number of different responses. 38.5% of the municipalities state that more than 90% of the water used comes from the public network. The use of groundwater from local aquifers is quite significant. Around half of the municipalities surveyed stated that 20% or more of their water resources come from local aquifers.

Regarding indoor uses in public buildings, 85% of the municipalities surveyed have taken actions to install water-saving systems in appliances or devices used in toilets (taps, urinals, WCs, etc.) over the past five years. In the remaining municipalities (15%), the respondents indicated that they had previously installed such devices.

The use in the last 5 years of alternative water resources other than the public network in public buildings was promoted by 30% of the surveyed municipalities. Furthermore, in more than 75% of the municipalities, all municipal buildings have individual meters.

Water consumption in municipal parks and gardens highlights the significant presence of resources other than the public network. Specifically, more than 75% of the municipalities have used alternative resources during the past five years. In addition to using water sourced from outside the public network, the city councils have carried out other saving measures: installation of more efficient irrigation systems; reduction of lawn sizes, and replacement of grass on the lawns with species that are less water intensive. Also noteworthy is the installation of individual irrigation meters in parks and gardens.

Regarding irrigation systems, sprinkler irrigation is the method most employed, used on more than 50% of the irrigated area in eight of the thirteen municipalities analysed.

To summarise the questions relating to the irrigation of parks and gardens, nine municipalities (70% of the total) agree that their parks and gardens require less irrigation water than in the past.

A special irrigation case can be found at sports facilities requiring turfed surfaces. Firstly, more than half of the municipalities state that they use water sourced from outside the public network, and about 30% have replaced the irrigation systems on their playing fields with other, more efficient systems in the past five years. However, due probably to the nature of the sports activities practiced, only in two cases have they reduced the surface area of the turf at this type of facility, although it is also true that in 50% of cases playing fields are now planted with species that are less water intensive. Overall, about 70% of the municipalities believe that they have reduced the water consumption at their sports facilities over the past five years.

As regards municipally-owned swimming pools, firstly there is notably a wide-ranging variation in terms of size and capacity due to the great variety in the number and characteristics of the existing facilities. In any case, more than 75% of municipalities reported that they have already implemented efficiency measures in the use of water (closed-circuit purifiers, mainly) prior to the period considered under this study.

On the basis of the responses, ornamental water uses, principally in public fountains, have also witnessed a trend toward falling consumption. Thus, more than half of municipalities have installed more efficient systems in their public fountains and more than half of municipalities believe that the use of water by such installations has decreased over the past five years.

As regards the washing and cleaning of public streets, about 70% of municipalities reported having modified their processes in order to save on water. A key element in this regard has been the use of alternative resources for this type of activity. Municipalities state that they use water sourced from outside the public network for street cleaning, mainly groundwater obtained from local wells. Overall, they state that they now use less water for these functions than five years ago.

Institutional policies regarding water also display a wide range of characteristics. One factor that appears to indicate municipal interest in better management of the resource are the so-called municipal water conservation regulations, enacted in particular following the development and implementation of the so-called 'Local Agenda 21' processes. Thus, only five municipalities (38% of the total) state that they have implemented such a legal remedy, while the rest have no such instruments. In any case, this is not an impediment to expanding water-saving policies to the various municipal services. For example, over 75% of

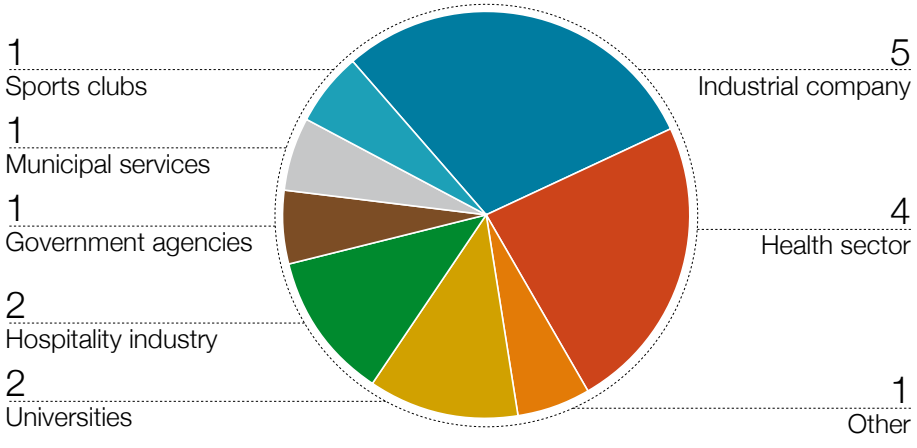
the municipalities claim to have carried out training activities to ensure better water management among municipal employees, while a predominantly monthly monitoring of consumption in the municipalities is also performed.

Finally, in the section on global assessments, around 70% of the municipalities stated that public water use in their districts has decreased over the past five years. The reasons given for this trend are varied but, in general, are mainly linked to greater awareness of the need to save water. In this sense, in all cases and without exception, the municipalities have stated that they have modified their municipal water management in order to reduce consumption.

Results of the survey on major consumers in relation to commercial and industrial activities in the municipalities in the metropolitan area of Barcelona served by Aigües de Barcelona

Below we present an analysis of results that is similar to the previous section but now for non-municipal industrial and commercial applications. Responses to the questionnaire in this section were received from 17 companies, covering a wide variety of registered customers ranging from automotive companies to hotel resorts to public universities, reflecting moreover the great variety of the activities included under this heading. Figure 21 shows the distribution of respondents by area of activity.

Figure 21. Distribution of respondents by area of activity



Source: Surveys of major consumers, 2014.

Table 21. Distribution (in %) of applications by type

	Sports clubs	Industrial company	Health sector	Municipal services	Univer-sity	Hotels	Gover-nment agency	Others
Services	40%	0-10%	30-90%	10%	40%	10-90%	40-70%	10%
Cleaning	0%	0-50%	10-30%	10%	0-20%	10%	20%	0%
Green areas	10%	0-10%	0-10%	10%	10%	0-10%	0-10%	10%
Landscaped sports facilities	30%	0%	0%	0%	0%	0%	0%	0%
Swimming pools	10%	0%	0%	0%	0-10%	0%	0%	0%
Ornamental purposes	0%	0%	0%	0%	0%	0%	0%	0%
Laundry	0%	0%	0%	0%	0%	0-90%	0-10%	0%
Kitchen	10%	0-10%	0-30%	0%	0-10%	0%	0-10%	0%
Industrial processes	0%	20-100%	0-10%	70%	0-40%	0%	0%	0%
Others	0%	0-50%	0-10%	0%	0-1%	0%	0-10%	80%

Source: Surveys of major consumers, 2014

Table 21 shows the distribution of water use within the different types of organisations surveyed.

The use of water in toilets (sinks, urinals, WCs, etc.) is one of the most significant. Around 50% of the institutions surveyed stated that consumption in this area accounts for 40% or more of their total water use.

In most cases (70% of the total) the water used comes from the public network. In one case, they used their own surface water, which covered only 10% of their total consumption, while in three other cases groundwater was used.

In over half of the cases (10 of 17), technical upgrades had been made to the toilets in these organisations, by incorporating appliances equipped with water-saving systems. In over 75% of cases, the installation of water-saving urinals was detected. Overall, therefore, most of the major consumers surveyed have toilets in which more than 50% of the devices are equipped with water-saving devices.

Cleaning tasks have also been optimised in more than 50% of cases, in order to save water.

As regards landscaped areas, overall, the adoption of water-saving and efficiency measures is not common, probably due to the low impact of this use. Even so, we should highlight the adoption of measures such as the use of alternative water sources, the installation of more efficient irrigation, the reduction of the surface area of the lawns and/or the planting of less water intensive species of grass or the installation of artificial turf. The prevailing irrigation system is that of sprinkling, while for the most part the source of the water is the public network.

The adoption by major consumers of changes in their production processes or in their overall operations in order to achieve improved efficiency in water use was mentioned in eight cases.

Overall, more than 50% of organisations say they have reduced their water consumption over the last five years. The reasons given to explain the trend towards the reduction in water consumption are, in order of importance, increased awareness of this issue in terms of water habits (seven cases); installation of efficient technologies (five cases) and the reduced activity of the company (three cases).

In no case were prices or taxes mentioned, nor the desire to use alternative sources. Finally, seven of the seventeen organisations have an environmental certification which, in five of these seven cases, includes improvements in water management.

5. CONCLUSIONS

5.1 General conclusions

From the study of the cases of Alicante and the municipalities in the metropolitan area of Barcelona served by Aigües de Barcelona in which decreases of 12.1% and 11.4% respectively in the consumption of drinking water were observed during the period 2007-2013, we can draw several conclusions regarding the causes of this decrease in water consumption in municipalities, which reached a high level of maturity in the water supply. These conclusions are listed below:

1) **Technical innovations:** In both plumbing systems and electrical appliances, great improvements in water consumption have been achieved. Savings of 40-60% compared with conventional models have been made. Aerators and diffusers to reduce water consumption by 40% and the installation of WC cisterns with dual flush systems also constitute a saving of up to 50%.

2) **Environmental awareness:** Since the mid-eighties this has been increasing in developed countries and has resulted in the modification of a number of personal and domestic hygiene habits, the repairing of leaks, the prevention of dripping taps, etc., which all favour a reduction in consumption. The creation and consolidation of this greater environmental awareness have been brought about by campaigns to promote water saving and the responsible use of water, involving both general activities at environmental fairs and other concrete actions including, in particular, those aimed at children. Moreover, the series of droughts have a great impact on drinking water consumption trends. During drought cycles, water saving campaigns have been developed whose messages affect consumption habits and remain after the period of drought is over.

3) **Ageing of the population:** One demographic aspect to bear in mind is the higher percentage of older people as a result of the ageing population and they are more conservative in their water consumption. In general, the percentage of the population aged over 65 is increasing in all municipalities. Along these lines, and bearing in mind their more conservative consumer profile, we could estimate that a person in the over 65 segment consumes on average 25% less than an adult in the previous segment.

4) **Housing and emigration:** Another demographic aspect that has an impact on consumption is the growth in single-parent families, which has favoured smaller-sized homes and, in principle, lower consumption rates. The number of houses no longer occupied is also increasing, as a result of immigrants and retired EU residents returning to their countries of origin. Equally, the emigration of the indigenous population to other regions or countries in search of work, and the decrease in the average size of family units, which from the 1980s up to the present day has dropped from 3.4 to 2.9 members, leads to a drop in consumption.

5) **Price:** The increase in the final invoice paid by users, together with the consequences of the current economic crisis, have resulted in their adoption of measures aimed at cost containment and, among these, decreasing water consumption in order to reduce their bills. Pricing systems with progressive rates favour awareness and water saving in consumers by penalising use over a certain consumption threshold. Additionally, this measure has also been encouraged as a result of the rising price of water purification, due to the principle of cost recovery. This aspect is particularly visible in certain types of residential and tourist housing, due to the advantages of the climate

on the Mediterranean coast, which leads to the existence of a large number of swimming pools, both private and communal. In virtually all of these pools, the water is maintained and treated instead of being replaced each year. One example is the impact that the sharp rise in the water rates in Catalonia since 2012, with the creation of a fourth consumption tranche subject to a progressive pricing scale (the price of the fourth tranche is 9 times higher than the price of the first tranche), has had on the decreases observed after that year in the municipalities with greater outdoor water use.

6) **Economic crisis:** With regard to domestic use, a decrease has been observed in the occupancy levels of second homes. This has led to a decrease in water consumption in these second homes, emphasizing their highly seasonal nature, concentrated in the summer months, with holidays now being significantly shortened due to economic reasons. Likewise, the effects of the economic crisis have been felt particularly in non-domestic uses, which on a whole have led to a 25% reduction in water consumption. This trend is more obvious in the commercial, catering and services sector, and has forced many businesses to close, or to choose to apply drinking water savings measures.

7) **Efficiency in the supply network:** The improvement in the network's performance is worthy of note. This means that the possibilities of increased consumption associated with leaks are currently nominal. In the case studies analysed, the companies have adopted various measures to achieve the continuous improvement of water performance, including those that highlight the investments made to renew and improve the state of conservation of the distribution network. So, it could be said that the optimum situation has been attained, inasmuch as carrying out additional investments would not be effective, since they would cost more than the hypothetical water saving. The investments made allow faults in the distribution networks to be reduced to the very minimum. In this respect, in their letters of intent to customers, some companies have included commitments that limit the interruption in supply caused by faults in the distribution network to a specific timeframe, promising to pay customers compensation if their service is interrupted for longer than the established time. Thus, it is likely that there will be a decrease in consumption in those municipalities that have the capacity to improve their water performance.

8) **Reuse of greywater and rainwater:** Although this has not yet been generalised, initiatives are starting to arise involving the reuse and use of greywater and rainwater in detached houses and commercial acti-

vities. These activities include the introduction if biological wastewater treatment systems and cisterns or tanks to collect rainwater.

9) **Climatic conditions:** As for the climate, the conditions that deviate from the so-called comfortable weather standards, should they be prolonged over time, may lead, at least partially, to a modification of personal consumption habits. A recent example of this, which had a notable impact on consumption, occurred in the first quarter of 2013 compared with the same period in 2012. During the first quarter of 2013, in a generalised manner all over Spain, the values of accumulated precipitation were higher than the same quarter the previous year, and the average monthly temperatures were lower than those in the corresponding quarter in 2012. Thus, we could deduce that the significant decrease in consumption during this period may have been caused by the climate.

All the abovementioned aspects could explain the reduction in per capita consumption, which in Alicante resulted in values of 119 litres/inhabitant/day and in Barcelona values of 105 litres/inhabitant/day. These particularly low values could indicate that they are close to the maximum savings level possible for technical devices and innovations introduced in baths and showers, more efficient household appliances and personal consumption patterns.

5.2 Conclusions on major consumers

The evolution of water consumption revealed by the water billing of major consumers, has followed a very similar trend to that seen in the domestic sector.

At times, large swings in the consumption values of some of the abovementioned major consumers were noted. These year-on-year variations are related to the existence of leaks, either within the facilities and the buildings served or in the water connections.

A high percentage of respondents, 83%, said that in the last five years water management at their organisation has been modified in order to reduce water consumption. The reasons given for this stance were mostly economic (60%). The remaining 40% were distributed equally between environmental awareness and having more efficient technologies.

The main causes that explain the decrease in water consumption by the major consumers are:

1) **Alternative sources of drinking water:** There are major consumers who have sought to reduce their bills for water sourced from the municipal distribution network, by using their own deposits or the increasing use of non-conventional sources to meet certain demands with reclaimed water, especially gardening. The substitution of drinking water by reclaimed water in the irrigation of public or private gardens points towards the likelihood that this process will only gain in importance in the near future.

2) **Renewal of equipment and improvement of facilities:** Savings in water expenditure based on the upgrade and renewal of equipment and facilities are becoming commonplace, and will likely become a permanent and widespread phenomenon.

3) **Modernisation of irrigation techniques:** The irrigation of all types of gardens, above all in the major municipal consumers, has incorporated modern techniques of localised and controlled irrigation, providing significant water savings.

4) **Economic crisis:** The situation of economic recession during the study period has led to a decline in activity in the manufacturing system, which has caused a sharp drop in water consumption.

6. TRENDS

The study suggests that recent developments in water consumption are due to a combination of factors, some of a structural nature, remaining over time, and others of a temporary nature, which would be expected to be reversible.

Some of the main factors of a structural nature include technical innovations, the efficiency of the supply network, raising the population's awareness, demographic changes and reuse. The economic crisis, meanwhile, would be classified as a factor of a temporary nature.

We anticipate that the evolution of domestic consumption in the coming years in municipalities in developed countries, which have reached maturity and achieved consolidation in their water consumption patterns, will continue its downward trend, but will be much more moderate than in recent years, as more efficient appliances continue to be installed and changes in consumption habits among citizens become firmly rooted. This will help consolidate lower per capita consumption. Nor do we expect a significant growth in population or a significant increase in the housing market in the short or medium term, which would compensate for the moderation in the per capita consumption.

In any case, what can help moderate the fall in domestic water consumption is the economic recovery in the sense that it will improve the occupation of second homes and the recovery of low-density housing.

With respect to non-domestic uses, we also expect a decrease, albeit more moderate, in water consumption as a result of the consolidation of technological advances and the widespread use of alternative sources of drinking water. However, in non-domestic uses, which are particularly affected by the decline in activity in the context of the economic crisis, we expect that as the economy begins to recover, we shall see an increase in water consumption, especially in commerce, where water use has been particularly affected by the economic crisis, resulting in the closure of businesses.

Moreover, it should be taken into account that the growing use of remote meter reading will allow greater control of water consumption by users, both domestic and non-domestic, likely leading to greater savings.

With regard to this last section, despite the fact that the use of this technology may lead to a possible reduction in consumption, it is important to consider the benefits of the use and commercialisation of remote meter reading, whether this be the more exhaustive control of meters and the performance of the network, or providing customers with access to functions enabling them to control and monitor their own facilities.

Along these lines, it is to be hoped that technological progress continue in innovation, both with regard to household appliances and irrigation installations and systems, helping achieve lower water consumption. The current regulation (Spanish Technical Building Code) also promotes efficient water consumption facilities.

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NOTES

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