WATER USE: PERCEPTIONS AND REAL BEHAVIOUR

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ABSTRACT

Freshwater is a strategic resource, essential for sustaining life and achieving sustainable development. Thus, potential water resources shortages critically demand for the promotion of efficiency gains in water uses. The literature suggests that policies to promote more rational water uses must take into account its multiple needs, and should be grounded in the consumer's characterization, namely the factors that might explain different consumption intensities.

This paper presents a research project, developed in collaboration with the water utility Águas de Coimbra, E.E.M. (*AdC*), that focus on the water consumption of residential consumers. The research motivation, objectives and methodology are presented in the initial sections of the paper, followed by a brief presentation of the most significant results. Finally, a set of considerations which intend to illustrate the potential of our findings will be offered, both in terms of consumer and operators' awareness of the need for rational use of this critical good, and the need for the development of actions to increase the "water resources perceived value".

Keywords: Water; Effective consumption, Perceived consumption; Determinants; Water charges.

1.   **INTRODUCTION**

About 75% of the planet surface is covered by liquid masses. However, freshwater represents less than 3% of that and only a third - in rivers, lakes, groundwater and atmosphere - offers potential for human consumption. For centuries, this illusion of abundance without limits allowed water to be considered as an inexhaustible resource. However, the rapid population expansion associated with growing concentrations in urban areas, as well as changing consumer habits and ever-increasing economic activities water footprint, have been stimulating the water demand to unprecedented levels. On the other hand, the overexploitation of water resources and climate change have been associated with detrimental environmental impacts. The combination of these forces makes it admissible the collapse of freshwater supplies, a threat that "may prove to be one of the most intimidating human history come across" (UNDP, 2007).

Thus, water resources management should involve intergenerational commitments and the definition of political and economic strategies that may lead to public awareness so that everyone has the opportunity and the knowledge to use it rationally. The literature on water demand issues points out the existence of low price elasticities of demand and suggests, among other explanations, "the poor perception that residential consumers have concerning the water pricing structures they face" (Martins, 2007). Aware of the limitations that characterize individual strategies, Corral-Verdugo (2002; 2003), Van den Berg (2008) and Kuhnen *et al.* (2009) argue that the greater the information, the greater the perceived value of the resource and the corresponding stimulus for action of either by the individual or other entities within the sector. In short, studies on personal characteristics and individual situational factors tend to be decisive for the promotion of proper standards of water consumption, providing an added value for policy development and consumption behaviour. Nonetheless, empirical literature on water demand has not dedicated much attention to determinants other than economic ones (price and income). Particularly neglected has been the analysis of consumers' awareness regarding the consumption patterns and the components of the corresponding water bills. Notwithstanding, more often than not the literature reveals problems, e.g., concerning the level of aggregation. Most studies on the residential water demand are supported by data aggregated at the municipal level and have a frequency that tends to exceed the billing period (Arbués *et al.,* 2003 presents a detailed survey of studies that focus on the estimation of residential water demand). Then, the

necessary procedures for setting up database for the representative family and to obtain monthly consumption tend to hide differences in consumptions associated with either the distinctive characteristics of households or seasonal variations in demand. As a strategy to overcome these limitations, this research project proposes to do the comparison between the observed consumptions and corresponding perceptions, confronting the water volumes billed by the company responsible for the delivery of domestic water supply and primary data collected at the family level with the application of a questionnaire survey to residential customers, in the city of Coimbra, a medium size Portuguese city. Accordingly, this strategy should be noted as an innovative attempt to study water issues considering a high level of detail and reliability.

The remaining of this communication is organized as follows. The following section presents some details on the methodological approach implemented. Section 3 provides a brief characterization of the sample for the completion of this research. In Section 4 we analyze the data on the perceived consumptions and actual consumptions and provide a set of alternatives ways to explore the comparison between these two dimensions. Section 5 concludes the communication, analyzing some of its main results and suggesting indications for future work.

2.   METHODOLOGY

The methodology for this project implementation includes, as a starting ingredient, the design of a questionnaire survey. The procedures for collecting primary data with the application of questionnaire surveys are complex. In this case, the usual difficulties were overcome with a flexible and interactive approachinvolving the close cooperation of the research team and the staff from *AdC*. The questionnaire completion phase was preceded by a meeting of the research team with the Administration, Finance Department and Information and Technology Department to identify the practical details and the technical and human resources to engage on the project implementation. This meeting also sought to gather guidelines on the organizational culture of the Company to inform the way the customers are to be approached, in person or by phone. These procedures were essential to establish, together with the commercial department, a strategy that allows the customers to be aware of the research goals and cooperative with them, without distorting the company's culture and the research process. An initial version of the survey was presented to the

Administration of the Company for discussion and suggestions. After had being considered some of the adjustments suggested, and once fulfilled all conditions deemed necessary (e.g., pilot simulations were performed to estimate the average questionnaire response time as well as to prevent any communication difficulties that might even subsist), the application process started considering a stratified sample of the population under study, i.e., all the residential customers of *AdC*. This stratified sample comprises 236 individuals distributed among the 31 parishes of Coimbra, having as criteria the number of residents according to the *2001 Census* and the principle of proportionality to ensure the minimization of errors of inference and sampling bias.

The final version of the survey comprises eight distinct parts according to the nature and purpose of information to be collected, namely: i) Explanatory notes and variables to identify the installation and describe the respondents, such as age, sex and residence (parish); ii) characterization of households dimension, age of their elements, education levels, professional activities and income; iii) characterization of the accommodation considering age, ownership, type (e.g., apartment), existence of specific areas that are part of the house such as a garage, garden, terraces, etc.; presence of residential equipments and appliances whose operation involves water consumption; iv) features of some of the most typical household services (e.g., if they are performed by some element of the aggregate or include a full- or a part-time maid (and for the latter, how many hours are considered); v) description of consumer habits concerning, e.g., the existence of outdoor facilities (e.g., swimming pool, car wash or balconies), machines that need water to operate, number of meals taken at home, number and duration of baths; vi) characterization of the habits to reduce consumption (e.g., flow reducing mechanisms, strategies to reduce bathroom discharges, leakages, washing machines without full load); vii) elements to typify the consumer perceptions *vs.* the consumer effective behaviours (e.g., cubic meters of water consumed, price, invoice value, tariff structure, value of the fixed charge and evidences that might justify the greater or lesser awareness, such as direct debit payments; viii) respondents environmental concerns (using a 5 point Lickert Scale), in order to obtain the level of agreement concerning statements about water scarcity, perceived value, rational uses, prices and actions leading to reduced consumption.

The application of the questionnaires, either by phone or in person, was done during July and August 2011, at *AdC* premises. The articulation of two application procedures

implicated different working methods, i.e., concerning the phone calls the procedure was to select an installation from the *AdC* costumers database randomly to avoid potential sample biases and then try to establish contact with the corresponding customer to implement the survey; in the case of customers contacted in person at the *AdC* premises, after an initial approach namely to confirm that the installation number or customer number was known (or to give that information) the questionnaires were completed and collected. Next, a preliminary data analysis was initiated to confirm if all the questions were answered properly and to confirm that it is possible to match questionnaires with the billing and consumption data provided by the utility *AdC*. Finally, the variables were coded in a single database. In parallel, from the *AdC* database of were extracted consumption records billed to the customers surveyed concerning the period from January 2009 until May 2011. This procedure allowed us to identify situations that should not be included in the study (e.g., facilities with zero consumption for a few months, abnormal water uses in a specific month or negative consumptions).

3. SAMPLE CHARACTERIZATION

The sample for this study comprises 236 residential users distributed throughout the 31 parishes of Coimbra (according to Santos (2004), these 31 parishes include 24 Predominantly Urban Areas, 5 Moderately Urban Areas and only 2 are Predominantly Rural Areas). The questionnaire surveys were administered mostly through telephone contact (67.8%), and the remaining were obtained by direct contact. About 47.5% (112) of respondents are male and 52.5% (124) female. Note that only 1.7% replied with reference to an installation that is not in the usual accommodation. The 236 installations correspond to 617 individuals, being the most representative households composed by two people, as shown in Figure 1.
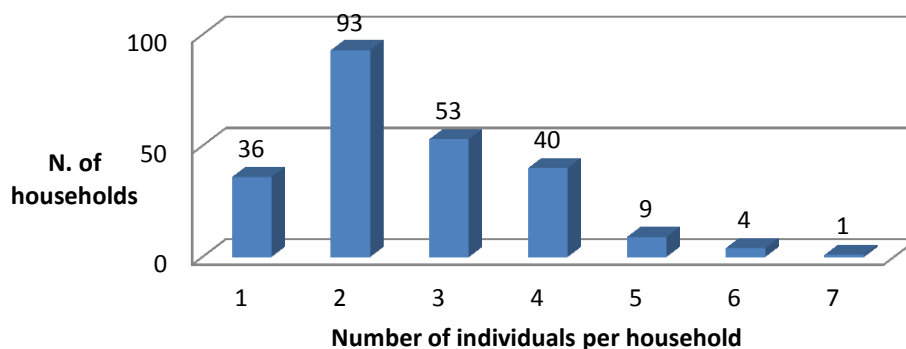
**Figure 1 -** Number of individuals per household: Histogram of absolute frequencies

The sample for this analysis includes mostly working age adults, mainly between 26 and 65 years old (as seen in Figure 2, this age group represents more than half of the sample). The respondents have an average age of 55 years old (the oldest is 93 years and the younger 20 years old).
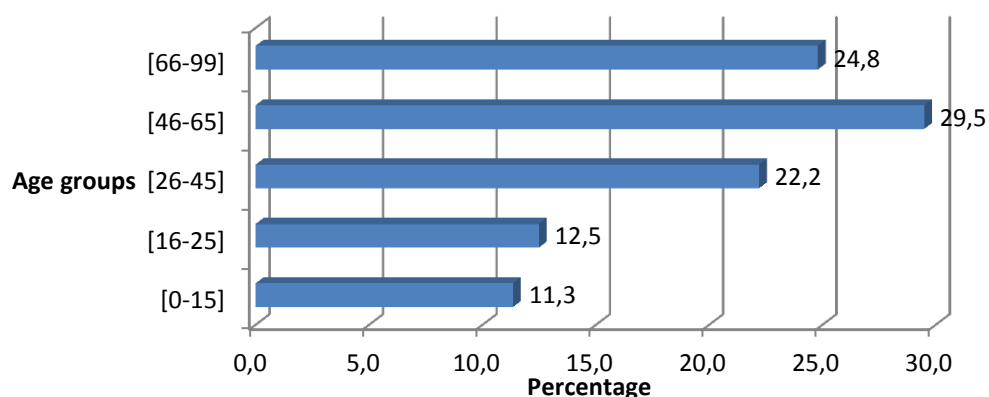
**Figure 2 -** Sample distribution by age group

Regarding the educational level 30.1% had completed higher education, 18.2% secondary education and 29.7% report qualifications at the basic level. In aggregate terms, a high percentage of the population with higher education is noted, being the sample median located on the secondary level. The sample includes a significant proportion of active population, which represents approximately 40.4% of the respondents. Of these, 90.4% carry out their activities in trade and services sector, 8% in industrial activities and only 1.6% in the primary sector. Only 2.1% of the respondents report that they are working on domestic services. Concerning the existence of elements of the corresponding household devoted exclusively to domestic service, 26.6% said yes and 17.7% reported the existence of a maid (on average14 working hours per week). The respondents average household income

lies between 530€ and 1300€ per month, as can be seen in the distribution shown in Figure 3.
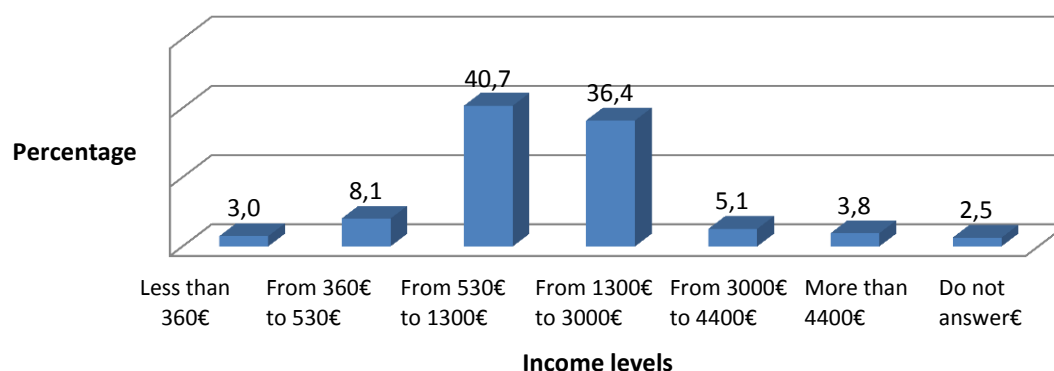
Figure 3 - Households by income

Concerning the individual's dwelling ownership, the majority of respondents (79%) are owners of the home where the water service installation is located, about 20% are renters and 1% live in a housing which is acknowledged as borrowed. The most common type of accommodation is the terrace housing (70%), of which 5.5% are identified as two-family dwellings. The remaining accommodations are apartments (29%) and condominiums with limited access (0.4%). About 20% of the houses have more than 50 years, although the greater part (54%) declared to have been built or rebuilt it for less than the last 30 years. With regard to the existing sanitary facilities, about one third reported to have dual-flush cisterns; 50.4 have only one shower and 16% have more than two; 19.5% do not have a bathtub, 65% have one and 15.7% two or more. The data concerning the questions about the possible existence of water consuming facilities outside the dwellings are summarised in Figure 4.
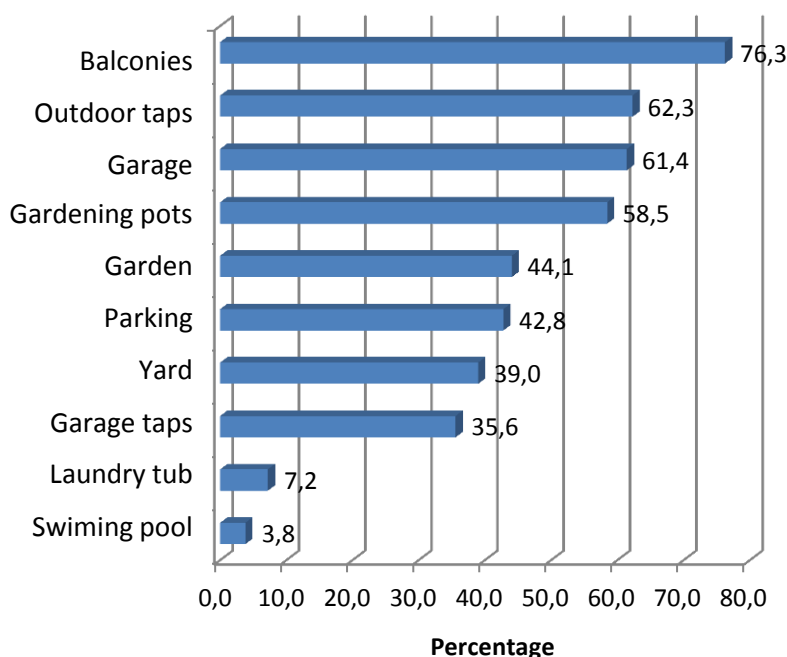
Figure 4 - Exterior water consumption facilities

Next, the data on consumer attitudes concerning water saving consumption practices confirm that respondents follow various strategies to reduce water consumption, especially in activities associated with daily hygiene and domestic tasks. About 97% reveals to systematically opt for shower instead of a bath, 89% stated turning off the tap while brushing teeth and 79% while soaping. A significant percentage of respondents (91%) stated being careful concerning the use of washing machines with full load and 70% avoids hand-washing dishes (piece by piece). It is also noted a vigilant attitude in favour of detecting and repairing leaks in valves and cisterns and reducing unnecessary discharge flushing. The data indicating relatively less favourable water saving attitudes include a relatively small use of flow reducers (14%) and the systematic waste of the shower water until warm up (34%). Finally, 46% of respondents who have exterior gardening spaces confirm that usually make use of tap water supply to support this activity, and 68% of those having access to water in outside spaces or garage use it for car washing. The data collected also allow an assessment of the activities intensity that may lead to increased water consumption, e.g., individuals who have a pool, use it on average during about four months a year; watering pots and garden in winter is not significantly, but in summer it usually happens two to three times per week; individuals who usually do car wash with tap water tend to make it at least once a month; the average number of showers per week per member of the household is six, with an average length of eight minutes; the number of lunches and dinners made at home, has

an average value of 5.5 and 6.6 a week respectively, and the average use of laundry and dish washing machines is 3 to 4 times per week, respectively.

These details are complemented with an assessment of the importance that people attach to environmental issues related to water resources and how these concerns may influence the perceived water resource economic value. For example, the data support the conclusion that respondents attach great importance to statements relating the scarcity of environmental resources to the extent that 87% of them fully agree that "water is the basis of ecosystems sustainability", 69% agrees that "it is urgent use of water rationally", 73% fully endorses that "water is a scarce good" and 75% disagree in absolute with the statement that "water never runs out." With regard to perceptions about the financial dimension (water price), the data show that a large majority (85%) disagree that "water tariffs are similar throughout the national territory." On the other hand, 71% of respondents disagree or somewhat agree, with the statement that "water rates are cheap"30% admit they are "willing to pay more because water is a basic need" and 47% shown to be "willing to invest in equipment to reduce water consumption."

4. COMPARATIVE ANAYSIS OF PERCEIVED CONSUMPTION *VS.* EFFECTIVE CONSUMPTION

4.1 Perceived Consumption

Apart from the study of the socio-economic dimension and consumption behaviours that characterize residential water users, the strategy followed to pursue the objectives settled for this research includes a third dimension intending to explore the perceived importance of consumption in terms of quantities consumed (cubic meters of water) and the costs arising therefrom (monetary units).

The first outcome of the assessment of perceived consumption highlights that only 13% of respondents assent to answer when asked if they had an idea of how many cubic meters, on average, they had consumed. Regarding the pricing structure, the answers are even more scarce (only 8.4% reported to know the pricing structure), and when they were shown the structures of possible prices, only 0.25% were able to identify the system of increasing block prices applied by *AdC*. Respondents were also asked to identify the number of blocks adopted by the *AdC*: 85% did not knew and only 2.1% were able to properly

identify four blocks (the correct number of blocks in place). It is relevant to point out a large dispersion in the responses. Indeed, when asked about the price of the sanitation services in comparison with to the price of the water supply services, 24% suggested that the price of the sanitation is cheaper, 38% consider it more expensive and about 46% answered not knowing. Regarding the perception of economic burden associated with consumption, 84% of respondents indicated the average value of the invoice, but only 6% of these were able to report the existence of a fixed part and none was able to identify its correct value.

4.2 Effective Consumption

This study considers that each household effective consumption corresponds to the cubic meters of water registered in *AdC* monthly database either obtained by company reading, communicated by the client or obtained by estimation. Accordingly, the monthly consumptions (from January 2009 to May 2011) of the same customers surveyed in the questionnaire were extracted from the *AdC* database. Besides the total monthly consumption, there were also estimated quarterly consumptions and consumptions by parish. A first analysis of quarterly consumption may be misleading, since it suggests the occurrence of higher consumptions in the autumn. However, this result can be explained by referring that the consumption is known only during the period after which the consumption is expressed. Hence, the consumption charged, for example, in September is not related to this month, but the previous month of August.

The analysis of the total consumption recorded in 2010 compared with 2009, shows an increase of 3.1%, being the most significant increases recorded in May, October, November and December. When analyzing the evolution of the annual consumption per season, there is a slight reduction in consumption during the summer months (-3.2%) and significant increases in autumn (10.4%), winter (14.5%) and spring (10%). The analysis of the dispersion data for the total consumption indicates the presence of higher dispersion than the average in the quarter corresponding to the summer months where the standard deviation is higher. However according to the trend line in Figure 5, it is possible to sign an increase in consumption in May and a decrease in November. These observations confirm the presence of a seasonality effect with record lower consumptions during the winter months and higher during the summer months.
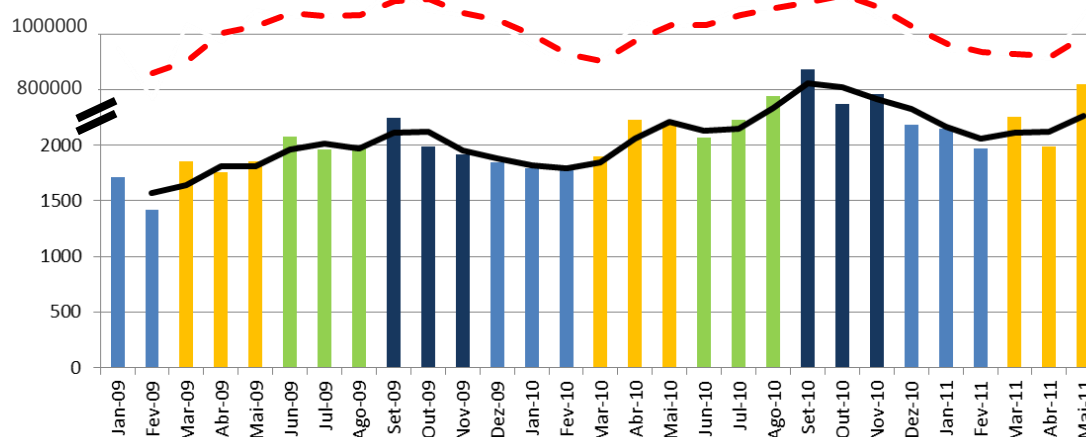
Figure 5 - Effective total consumption (m^3) 01/2009 - 05/2011

The monthly comparison of actual consumptions of those included in the sample with the total actual monthly consumption of the entire population, seen by the trend lines of the moving average for two periods (Figure 5) shows similar trends. Considering data on total consumptions and the number of individuals of the household *per capita* consumptions were calculated over the 29 months. The parishes which recorded a higher *per capita* consumption *in* the period analysed were Antanhol and Almalaguês with 173 and 167m^3 respectively. At the opposite side are the parishes of Almedina and Vil de Matos with consumptions of 17 and 27m^3 respectively.

At a more detailed level, an analysis of the determinants of residential water consumption was done. In each column of Table 1 various characteristics for the households whose consumption belongs to each block are provided.

	Water tariff block			
Household's characteristics	1st block [0 - 5m^3]	2nd block]5 - 15 m^3]	3rd block]15-25 m^3]	4th block > 25 m^3
Average household size (#)	2,2	2,5	3,3	4,2
Average age (years)	49	46	47	34
Average income (€/month)	[530-1300]	[530-1300]	[530-1300]	[1300-3000]
Education level	Basic	Basic	Secondary or higher	Secondary or higher
Perc. of workforce elements (%)	40	39	53	37
Percentage of pensioners (%)	39	33	20	10
Percentage of students (%)	13	21	16	47

Table 1 – Determinants of water consumption (per water tariff block)

As expected (following other available empirical studies) Table 1 data allows one to confirm that residential water consumption increases with the average household size or the average income and decreases with the percentage of pensioners. Concerning the relationship between education level and water consumption it is also possible to validate a positive relationship between these two variables. This direct relationship may be due to the condition that higher education levels are closely associated with higher levels of income and greater utilization of intensive water user facilities and structures. However, one would also expect that citizens with higher education have more consolidated environmental concerns and, as such, are more parsimonious users of a scarce resource. It is also possible to become aware of a positive link between the percentage of students and water consumption and, in reverse, between water consumption and the percentage of active population members (which may also be related with the number of students and the expected time spend at home). Another result refers to the confirmation of the inverse relationship between water consumption and the household mean age.

4.3   Perceived Consumption *vs.* Effective Consumption

In order to analyze "perceived consumption" dimension, i.e., if consumers have reasonably accurate perceptions of their consumption, the questionnaire respondents were asked to situate the monthly consumption of their households in one of the four blocks included in the water supply tariffs. This exercise indicates significant lack of knowledge of water volumes actually consumed, in that only 24% of respondents indicated an estimate, with the remaining 76% admitting that they were not able to answer that question. As can be seen on Table 2, the 24% of respondents who provided an estimative of their consumption blocks, 38.6% ranged their consumption in the lowest (first) block (64% were correct); 31.5% said belonging to the block between 5 and 15 m3 (65% were correct); and 8.8% said belonging to the highest consumption block (no one was correct). In global terms, only 12.7% of respondents place a correct estimate about their consumption blocks. Of those, 47% belong to the first block and 43% to the second one. Table 2 provides information about the relationship between perceived and actual consumption, detailed by water consumption block.

Consumption Block	Perceptions of total surveyed (%)	Perceptions of those accepting to answer (%)
Do not answer	75,8	--
Answer	*24,2*	--
[0 - 5m^3]	9,3	38,6
]5 - 15m^3]	8,5	35,1
]15 - 25m^3]	4,2	17,5
> 25m^3	2,1	8,8
Total	*100*	*100*

Table 2 – Assessment of consumption perceptions (per volumetric block)

According to the analysis of data on consumer perceptions, one can also conclude that respondents associated with higher monthly consumptions (more than 25m^3), tend to over or underestimate their consumption as all of them were unable to correctly identify the level of consumption that corresponds to the actual household consumption. Interestingly, the perception of the consumers is higher in the two blocks of lower consumptions, in that the proportion of correctly perceived consumption tends to decrease as one considers the higher consumption blocks. In summary, the results suggest that the larger the volume of water consumed less likely it is the knowledge that these residential customers have concerning their actual consumptions. A possible explanation for this result is that if higher levels of water consumption are related to higher income levels then residential users who consume more, are less concerned with the total value to be paid.

The other line of analysis followed to complement this approach involved the comparison between the "perceived charges" (obtained from the questionnaire) and charges actually supported by each household (obtained from the *AdC* database). For the "effective consumption charges" the monthly consumption records (provided by the *AdC*) were considered, from which the average monthly water charges per household were calculated. Lastly, in order to compare the economic burden (obtained from the *AdC* database) and the perceived charges (obtained in the questionnaire) it was calculated the difference between the value indicated by the client as the average value of their bills and the average value invoiced by *AdC* costumers.

The comparison of the series concerning the "perceived charges" and "effective charges" shows that 41% tend to underestimate the burden and 59% overestimate what they actually paid. However, when considering the respondents which correctly placed the

water charges, results indicate a close correspondence between "perceived charges" and "effective charges". Of the 12.7% of respondents that placed a correct estimate about their consumption blocks when asked about the perceived charges, about 60% indicate a value which has a total deviation of less than 5 Euros. In relative terms, 26.6% presents a perception deviation that is lower than a relative 10% deviation, and 13.3% between 10 and 20%. In brief, about 40% of respondents that have showed a fairly accurate perception of water quantities consumed also have perceptions on charges (i.e., the financial burden) that are close to the effective charges.

5.   CONCLUSIONS

Following the water scarcity recognition, a wide range of legislation, whether national and multilateral, as well as the related economic literature, suggests that the promotion of rational use of residential water should be supported by a thorough characterization of consumers and consumptions. However, there are still few studies in which these dimensions are analyzed in an interdependent and systemic way. This paper presents an exploratory analysis and a characterization of residential water consumers in the city of Coimbra combined with an empirical evaluation of their perceived and actual consumptions. This research objectives involved the collection of primary data through the application of a questionnaire survey (designed originally for this project), applied to the residential customers of *Águas de Coimbra, EEM*. In parallel, we proceeded to the comparison of primary data about consumer perceptions with the official historical consumption volumes and charges. Both the use of primary data at the household level to overcome the usual problems of aggregation, and the data obtained directly from the *AdC* costumers database (as regards actual consumptions for the residential customers) give this research project innovative and unique features.

The sample characterization reveals a population mainly of working age elements, employed mostly in trade and services sector, with an income average between 530 and 1300 Euros. The households' characterization shows that much of the housing accommodations comprise own built or rebuilt (in the last 30 years) houses. The assessment of consumption habits confirms, on the one hand, the existence environmental concerns embodied in practices that indicate the intention to reduce the resource use and, on the other hand, there is an apparent lack of knowledge about the consumption levels and the

corresponding pricing implications. In fact, the identification of behaviours to reduce water consumption allowed one to highlight the effective contribution that is associated with activities associated with daily hygiene and domestic tasks. However, it is noted the persistence of indicators that point to the possibility of strengthening the economy of the resource, including those relating to the use of reducing consumption devices.

The data on "consumption perceptions" and charges made available information which was subsequently compared with actual consumptions and actual charges. The analysis of consumption volumes, allows the identification of consumption seasonality, as would be expected, and confirms the existence of higher consumptions in areas of lower population density, and lower consumptions mainly in urban parishes. The comparison involving perceptions *vs.* real data shows that consumers have "charges perceptions" closer to reality than what concerns to actual volumes consumptions. The results also suggest that the smaller the aggregate consumptions, closer to the real values are the corresponding perceptions, either in consumption volumes or corresponding charges.

Finally, the knowledge that this study allowed us to build underline the existence of multiple lines for future research. A pertinent line of research concerns the discussion of the determinants of water perceived and actual consumption by residential users; other concerns the estimation of the demand function from that set of observations. From the completion of these analyses, policy suggestions are expected for promoting appropriate standards of consumption and a clarification of signalling elements of such consumption, including an important more clear and transparent tariffs design.

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