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Household Water Consumption: Insight from a Survey in Greece and Poland

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Abstract

Determining the behavior of domestic water consumers can facilitate a more proactive approach to water demand management, and serves as the foundation for the development of any intervention strategies that seek to bring about sustained and substantial reductions in domestic water consumption. As part of the European Union (EU) funded project Integrated Support System for Efficient Water Usage and Resources Management (ISS-EWATUS), a household water consumption survey was administered to address the question of how water was used within the home in the EU. The survey was distributed by the University of Thessaly in Greece, and the Institute for Ecology of Industrial Areas in Poland. This paper represents the research output of the survey, including the analysis of three major elements pertinent to the behavior of domestic water consumers: end use behaviors; socio-demographic and property characteristics; and psychosocial constructs such as attitudes and beliefs.

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Keywords: Household water consumption; Consumer behavior; Survey

1. Introduction

Population growth, expansion of business activity, urban development, water pollution, climate change and drought have contributed to increased water scarcity in many parts of the world. It is estimated that a fifth of the world's population live in areas of physical water scarcity, where there is not enough water to meet all demands. One

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third of the world's population does not have access to clean drinking water. A further one fourth of the world's people live in areas of economic water scarcity, where poor management makes it impossible for authorities to satisfy the demand for water.[1] In Europe, at least 11% of the population and 17% of the territory have been affected by water scarcity to date.[2] The number of areas and people affected by droughts increased by almost 20% between 1976 and 2006.[2] In 60% of European cities with more than 100,000 people, ground water is being used at a faster rate than it can be replenished.[3] In response, the European Commission has advocated the creation of a water efficient economy and the promotion of a sustainable water usage culture across Europe.[4]

The project Integrated Support System for Efficient Water Usage and Resources Management (ISS-EWATUS) was proposed to develop several innovative Information and Communications Technology (ICT) methods to exploit the untapped water-saving potential in the European Union (EU). At the household level, this is achieved by the development of a decision support system to provide the householders a good awareness of their daily water consumption in a meaningful and effective presentation, and in turn, promote water consumption reduction.

Key components in developing decision support system are to address the elements of 'what', 'why', and 'how' of household water consumption behavior. The element of 'what' tell what has happened in the household regarding its disaggregated water end use. The element of 'why' identify the psychological reasons associated with consumers' daily water consumption practices. The element of 'how' indicate how the behavior intervention could be applied to the domestic water consumers based on the elements of 'what' and 'why' obtained.

This paper represents the research output of a household water consumption survey conducted in Greece and Poland. The survey, by collecting consumers' self-reported information on water end use behaviors, socio-demographic and property characteristics, and psychosocial constructs (e.g. attitudes and beliefs), was designed to address the element of 'what' of household water consumption behavior. In the following part of the paper, we will first illustrate relevant literature that built up the theoretical basis of the questionnaire design. We will then present and discuss the data obtained.

2. Theoretical Background

The survey design was informed by an extensive literature review. The review indicated the necessity of three major categories of information to be collected from household water consumers. They are water end use behaviors, socio-demographic and property characteristics, and psychosocial constructs (e.g. attitudes and beliefs).

2.1. Water end use behaviors

'End use' refers to sites where water is used in the home, such as toilets, showers and washing machines. Water end use behaviors indicate the breakdown of water consumption activities that occur in people's daily lives. This information could help identify appropriate targets for behavior change interventions relating to daily use of water. High quality information in this area is limited as the results of empirical studies are often recorded in the form of non-peer reviewed technical reports, case studies and consultancy reports.

According to data analysed by the Energy Saving Trust [5], showering accounts for a quarter of the water consumed within UK households. In the Netherlands, a population survey indicated that the main end uses of household water were shower (40 per cent), toilet (28 per cent) and washing machine (12 per cent).[6] Analysis of the North American Residential End Uses of Water study [7] indicated that, in single-family homes, more than half of the water consumption was taken by outdoor activities (58.7 per cent), e.g., irrigation and use of swimming pools while, for indoor end uses of water, the top three activities were toilet flushing (26.7 per cent), using the washing machine (21.7 per cent) and showering (16.8 per cent).

In Australia, Beal, Stewart and Huang [8] estimated average water end use consumption based on data from published studies and suggested the following end use allocations: shower (25 per cent); outdoor uses (21.9 per cent); taps (19.0 per cent); washing machine (17.6 per cent) and; toilet (12.7 per cent). The relatively low consumption of outdoor uses was attributed to region specific factors such as climate, plant species, restriction regime and garden size.[9][10]

2.2. Socio-demographic and property-related characteristics

Socio-demographic characteristics include household size, educational level, income, age and gender. The theorised association between household income and engagement in water saving behaviours is ambiguous. A high income facilitates purchase of more efficient appliances; however, this saving may be negated by a reluctance to modify habits, for example, by delaying using the washing machine until a full load has accumulated.[11] By contrast, lower income households may be less likely to engage in efficiency (purchasing) measures but may have money-saving habits, such as only using a washing machine when there is a full load.

Grafton, Kompas and Ward [12] conducted a survey in ten countries (Australia, Canada, Czech Republic, France, Italy, Korea, Mexico, Netherlands, Norway and Sweden) and report that household size, educational level and income had positive and significant effects on household water consumption. This is supported by Gregory and Di Leo's study [13] in Shoalhaven, Australia where these three factors (as well as the age composition of household members) had a significant influence on household water demand. Clarke and Brown [14] investigated factors that influence community receptivity to using alternative water sources (such as grey water) and water-saving technologies at the household level. They found that demographic characteristics had an impact on the ability and capability of individuals to acquire and apply household water saving and water recycling measures. Makki et al. [15] explored the predominant determinants of shower end use consumption, based upon the 200 households in Australia. They found that the presence of females and children (and teenagers, in particular) was associated with increased shower water usage.

The property characteristics rubric covers house size and the presence or absence of a garden, pool or water meter. A plurality of studies argue that outdoor uses (e.g., garden irrigation, cleaning driveways, filling swimming pools, etc.) are more discretionary than indoor usage; consequently, they are often the primary target for strategies to change water consumption behaviors.[16][17] Syme et al. [18] report that block size, swimming pool ownership and the centrality of the garden in the lifestyle of a household had a significant impact on external water use.

2.3. Psychological constructs

It has been widely acknowledged in the literature that psychological constructs, such as attitudes and beliefs, are essential determinants of consumers' actual behaviour.[19][20] Specific to water consumption, Corral-Verdugo et al. [21] conducted research in urban areas of Mexico and found that general environmental beliefs affected specific beliefs regarding the use of water, and these in turn correlated with the measure of water consumption. Gilg and Barr's study [22] of 1265 households in Devon, UK indicated that committed environmentalists and main stream environmentalists were most likely to engage in energy and water saving activities regularly. In the exploration of the relationship of knowing or having the knowledge on how to conserve water and whether this translational into actual behaviour, Middlestadt et al. [23] found that students who were exposed to a curriculum of water conservative behaviours more regularly performed these behaviours. In CSIRO's investigation of water end use in Perth, Australia, attitudinal variables were found to affect outdoor water consumption.[24] In most recent research on 132 detached households in the Gold Coast, Australia, Willis et al. [25] found that residents with very positive environmental and water conservation attitudes consumed significantly less water than those with only moderately positive conservation concern.

3. Methods

Following the theoretical background reviewed in the literature, the questionnaire consisting of 43 questions was designed, covering above three major categories of characteristics of household water consumers. The questionnaire was then distributed by the University of Thessaly (Greece) and the Institute for Ecology of Industrial Areas (Poland). In Greece, to achieve the best possible diversity, a 'paper and pencil' approach was applied whereby water company residential customers were approached when they came to pay their water bills. In Poland, a link to the web-hosted survey was circulated among Institute employees and employees of the partner water company in

Sosnowiec. In total, there are 77 cases from Greece, and 41 from Poland. The data collection period was November and December 2014.

4. Results and Discussions

4.1. Socio-economic and property characteristics

As illustrated in Table 1, in both countries, the majority of respondents were aged between 25 and 44. Regarding educational status, respondents from Poland were almost exclusively highly educated while those from Greece had greater diversity. The difference possibly reflects the different approaches to data collection in Greece and Poland. In addition, around half of the Polish respondents who disclosed their household income, were above the national average level (3647 PLN).[26]

Table 1 Distributions of age, education, and household income of responses from Greece and Poland

A. Greece

Age Ranges	Distributions		**Educations**	Distributions		**Monthly Household Net Income (€)**	Distributions	
	Frequency	Percent		Frequency	Percent		Frequency	Percent
16-24	12	15.6	Junior Middle school or below	7	9.1	<1000	26	33.8
25-44	42	54.5	High School	22	28.6	1000-1500	25	32.5
45-64	21	27.3	Technical School	20	26.0	1500-2000	13	16.9
65-74	2	2.6	Junior college	9	11.7	2000-2500	4	5.2
75+	0	0.0	College / university	14	18.2	>2500	1	1.3
Totals	77	100.0	Above university	5	6.5	Totals	69	89.6
			Totals	77	100.0	Don't wish to disclose	8	10.4
			Missing	0	0.0			

B. Poland

Age Ranges	Distributions		**Educations**	Distributions		**Monthly Household Net Income (PLN)**	Distributions	
	Frequency	Percent		Frequency	Percent		Frequency	Percent
16-24	0	0.0	Junior Middle school or below	0	0.0	<1000	1	2.4
25-44	32	78.0	High School	0	0.0	1000-2000	5	12.2
45-64	9	22.0	Technical School	2	4.9	2000-3000	3	7.3
65-74	0	0.0	Junior college	0	0.0	3000-4000	3	7.3
75+	0	0.0	College / university	32	78.0	>4000	8	19.5
Totals	41	100.0	Above university	6	14.6	Totals	20	48.8
			Totals	40	97.6	Don't wish to disclose	21	51.2
			Missing	1	2.4			

As depicted in Figure 1, the household size of respondents from Greece and Poland had a mean number of 3.60 and 2.81, respectively. The figures at national level are 2.80 in Greece, and 2.76 in Poland.[26][27]

The respondents' property ownership, types, ages, and water related facilities (i.e., garden, swimming pool, and water meter) were recorded.

As illustrated in Figure 2, 48 per cent of the respondents from Greece and 83 per cent from Poland had owned their properties. This figure at national level is 74.3 per cent in Greece and 65.3 per cent in Poland.[26][27] Property types are mostly detached houses in Greece and apartments in Poland. The majority of properties are aged between 6 years to 54 years both in Greece and Poland, excluding unknown responses.

In terms of essential water-related facilities such as garden, swimming pool and water meter, our data (Figure 1) suggested that nearly half of the respondents from Greece have a garden, but most do not have a swimming pool. In

Poland, there are similar distributions regarding gardens and swimming pools, but there is almost universal water meter coverage.

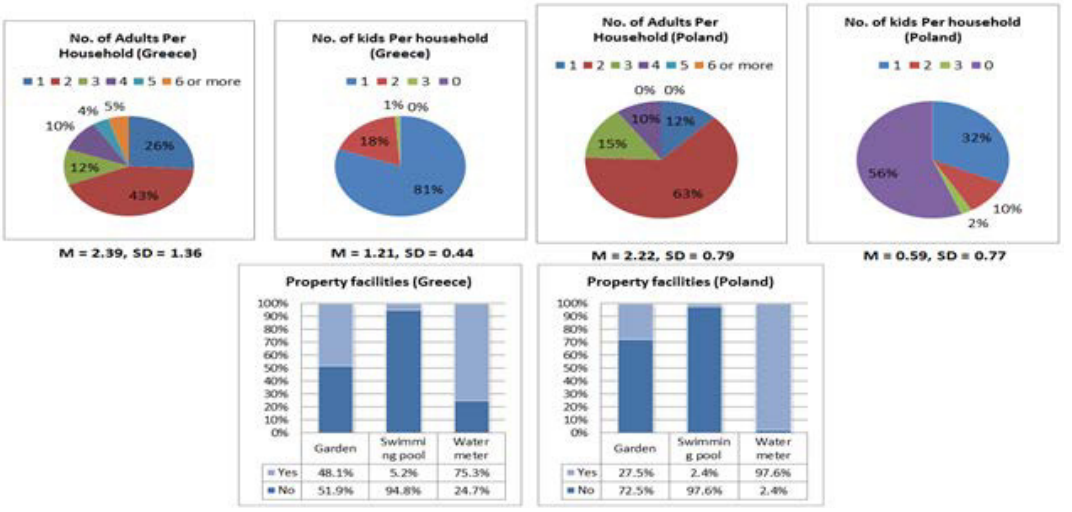


Fig. 1. Household Size.& Property Facilities

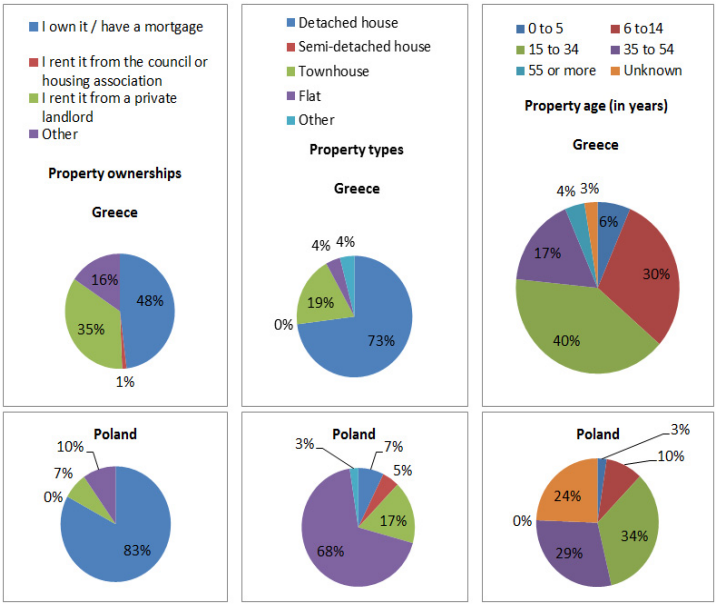


Fig. Property Ownerships, Types, and Ages.

4.2. Water end use behaviors

As one major activity of household water consumption, responses on household shower frequency, shower time and shower length were collected (Figure 3 & 4). The data model suggested that male adults and children took shorter showers than female adults, and children took fewer showers per week than adults, both in Greece and in Poland. This is in contrast to the literature [8][15], which argues that the presence of teenagers significantly increases the volume of water consumed for showers.

Most household members take a shower during the evening. Most have not tried to take shorter showers at all; this indicates the potential for a water conservation intervention.[28]

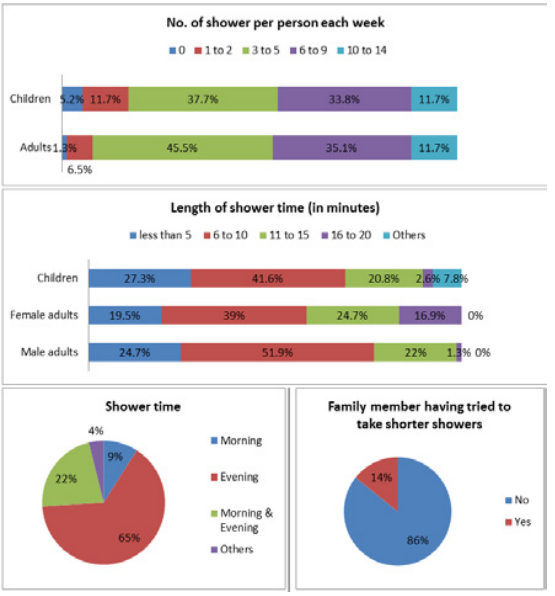


Fig. 3. Shower End Use (Greece)

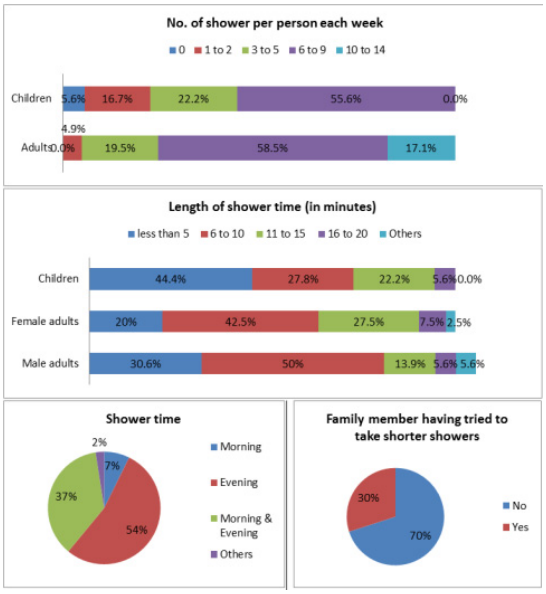


Fig. 4. Shower End Use (Poland)

As another major source of household water consumption, water end use behaviors relating to gardening, was collected (Figure 5). The data suggested that the frequency of gardening during summer time was quite diverse, both in Greece and in Poland. A large proportion of 'other' responses indicated that many households watered their gardens on a non-regular basis. Irrigation systems for gardening were exclusively traditional; no sprinkler was identified. A small minority of respondents collected rain water for gardening, which suggests another potential for water conservation intervention in the future.

One inefficient water use practice is running water continuously without collecting it in a sink or bowl. The responses suggested that three major occasions when this occurs are waiting for hot water during winter, hand-washing dishes, and brushing teeth, (Figure 6). They could be primary targets of future behaviour intervention.

Previous literature has also addressed the association between water efficient technology and reduced water demand at the household level.[25][29][30][31] Our data on the household application of water saving appliances suggests that respondents from Poland have many more water saving appliances than those in Greece (Figure 6). This may be associated with the greater coverage of water meters and the higher socio-economic status of the respondents.

4.3. Conservation attitudes

Finally, information was collected on respondents' perceived daily water consumption and their motivation for using water efficiently as well as attitudes towards different ways of conserving water.

The data suggested that most respondents estimated their personal water consumption to be low with 82 per cent of Greek respondents and 63 per cent of Polish respondents choosing one of the two lowest water usage options provided (Figure 7).

The data also suggested that three major motivations to use water efficiently at home are to save water, to help the environment, and to save money (Figure 7). This information may inform the direction and focus of future behaviour intervention, especially related to the knowledge intervention dimension. In addition, the different order of these three major motivations between respondents of Greece and Poland may reflect their different distributions of water meter installation as illustrated in Figure 7. The installation of water meters makes monetary water

consumption sensitive to the actual water usage. Respondents from Poland (where water meters were almost universal) chose saving money as the most widely acknowledged motivation for using water efficiently. In contrast, most of the responding households in Greece have not installed a water meter; they were less likely to choose this rationale for saving water. The literature has indicated that price structuring may have a direct influence on household water use.[32][33]

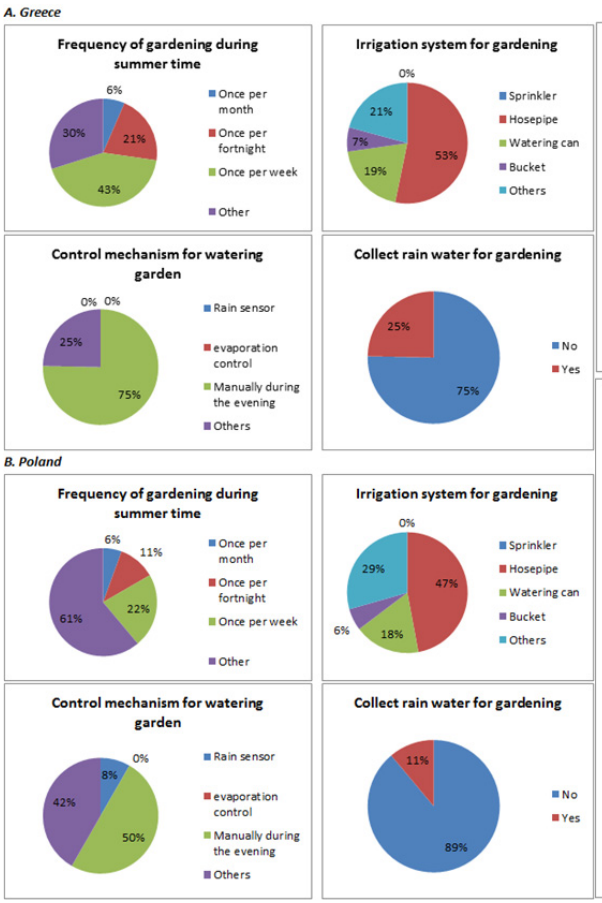


Fig. 5. Water End Use for Gardening

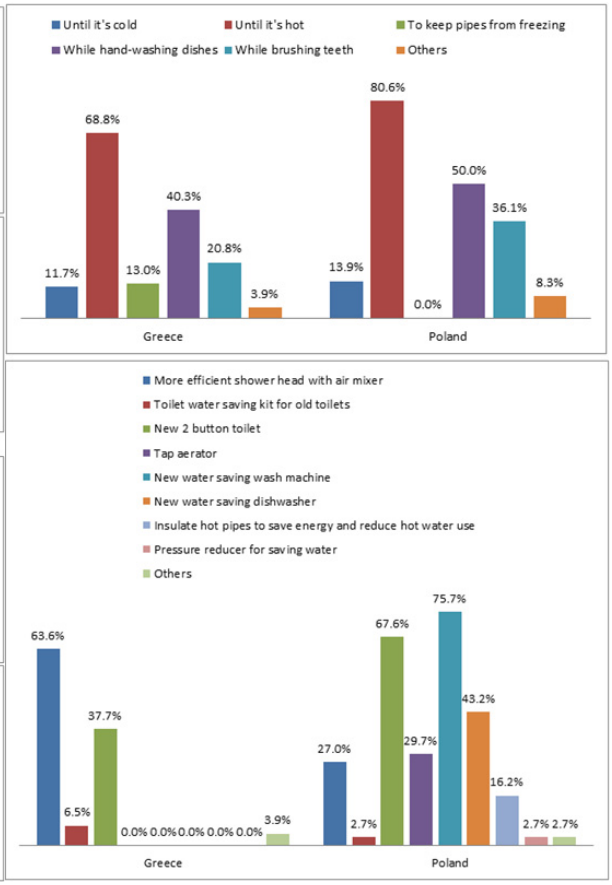


Fig. 6. Inefficient Water Use & Water Saving Appliances

Attitudes towards different strategies for water conservation intervention, i.e. knowledge, mandatory water restriction and adjusted water prices, were measured through three separate statements (Figure 7). The data suggested that most of the respondents would be responsive to all three intervention strategies.

4.4. Bivariate analysis

The literature has suggested that larger families are usually more water efficient on a per capita basis due to economies of scale.[8][34] Accordingly, shower end uses, as one of the essential indicators of water efficiency, were compared between different household sizes in our data model.

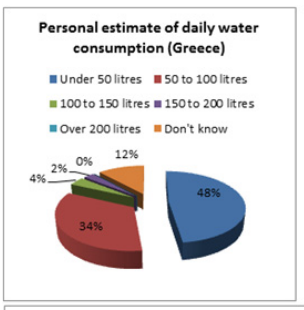
Household sizes were dichotomized into two groups by their mean values (Figure 8). Household shower length was indexed through the arithmetic average of shower length of household members, in which each shower length category (‘less than 5’, ‘6 to 10’, ‘11 to 15’, ‘16 to 20’, ‘other’) was replaced with an ordinal scale from 0 to 4 in the calculation. The household shower frequency was indexed through the arithmetic average of shower frequency of household members, in which each shower frequency category (‘0’, ‘1 to 2’, ‘3 to 5’, ‘6 to 9’, ‘10 to 14’) was

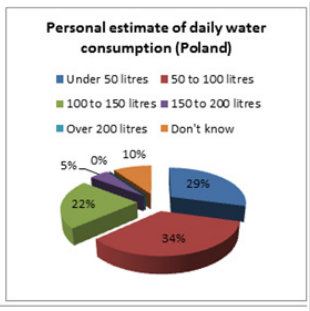
replaced with an ordinal scale from 0 to 4 in the calculation. Household shower end use, as a general indicator of household water efficiency for showers, was further indexed through multiplication of the household shower length index and household shower frequency index.

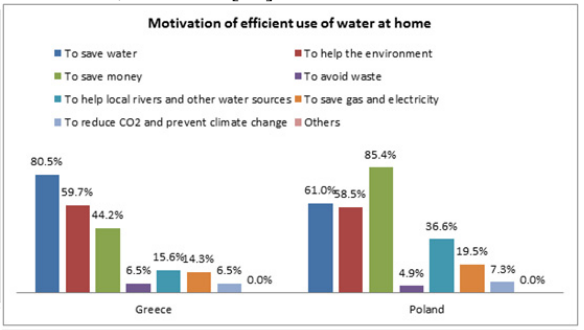
The comparison suggested that data from Poland supported the argument from the literature; households of above average size were more efficient in terms of shower length and general shower end uses. However, data from Greece generally contradicted this claim, with smaller households being more efficient users of water through shower use. This controversy may be attributed to the fact that we were measuring shower end use efficiency solely rather than the overall efficiency of household water consumption.

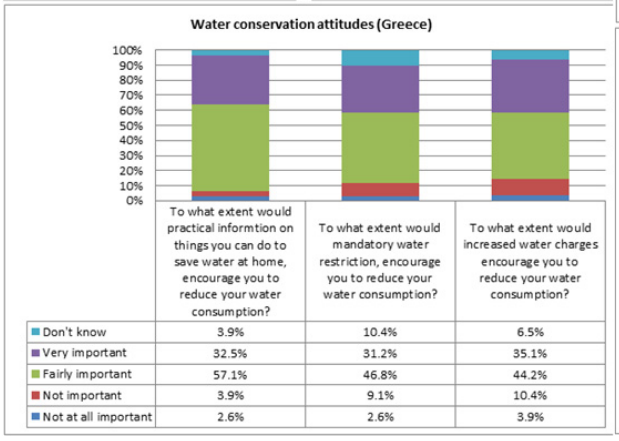
The literature has also reported higher water consumption per capita for higher income homes.[35] Accordingly, the household shower length index, household shower frequency index, and household shower end use index, were compared among different household income levels in our data model. As depicted in Figure 8, household income categories were dichotomized into two groups by their median levels. The comparison suggested that data from Greece supported the above argument, with higher income households consuming more water via shower use. By contrast, among the Polish households, lower income households used more water by showering. This inconsistency of results between Greece and Poland, again, is attributed to the fact that we were measuring the shower water consumption solely rather than the overall household water consumption per capita. In addition, around half of the Polish respondents refused to provide their household income.

Finally, it has been argued that responsiveness of demand to changes in price is greater for home owners than renters in California, US.[33] Accordingly, household ownerships were dichotomized into two groups (owners vs. renters), and their water conservation attitudes towards adjusted water charges were compared, where the five categories of attitudes were scaled in order (‘Not at all important’ -> 0, ‘Not important’ -> 1, ‘Don’t know’ -> 2, ‘Fairly important’ -> 3, ‘Very important’ -> 4). As depicted in Figure 7, data from Poland supported the argument, where home owners were more inclined towards price change of water than the home renters. Data from Greece suggested a minimum difference. Maybe it is due to the contested role of price on household water consumption as water use has also been found to be unresponsive to pricing in Brisbane, Australia.[36]

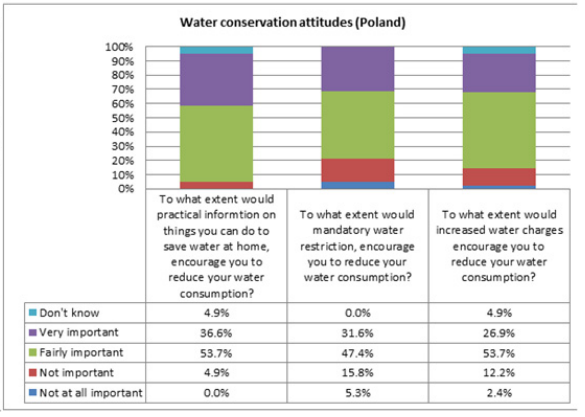








	To what extent would practical informtion on things you can do to save water at home, encourage you to reduce your water consumption?	To what extent would mandatory water restriction, encourage you to reduce your water consumption?	To what extent would increased water charges encourage you to reduce your water consumption?
Don't know	3.9%	10.4%	6.5%
Very important	32.5%	31.2%	35.1%
Fairly important	57.1%	46.8%	44.2%
Not important	3.9%	9.1%	10.4%
Not at all important	2.6%	2.6%	3.9%



	To what extent would practical informtion on things you can do to save water at home, encourage you to reduce your water consumption?	To what extent would mandatory water restriction, encourage you to reduce your water consumption?	To what extent would increased water charges encourage you to reduce your water consumption?
Don't know	4.9%	0.0%	4.9%
Very important	36.6%	31.6%	26.9%
Fairly important	53.7%	47.4%	53.7%
Not important	4.9%	15.8%	12.2%
Not at all important	0.0%	5.3%	2.4%

Fig. 7. Conservation Attitudes

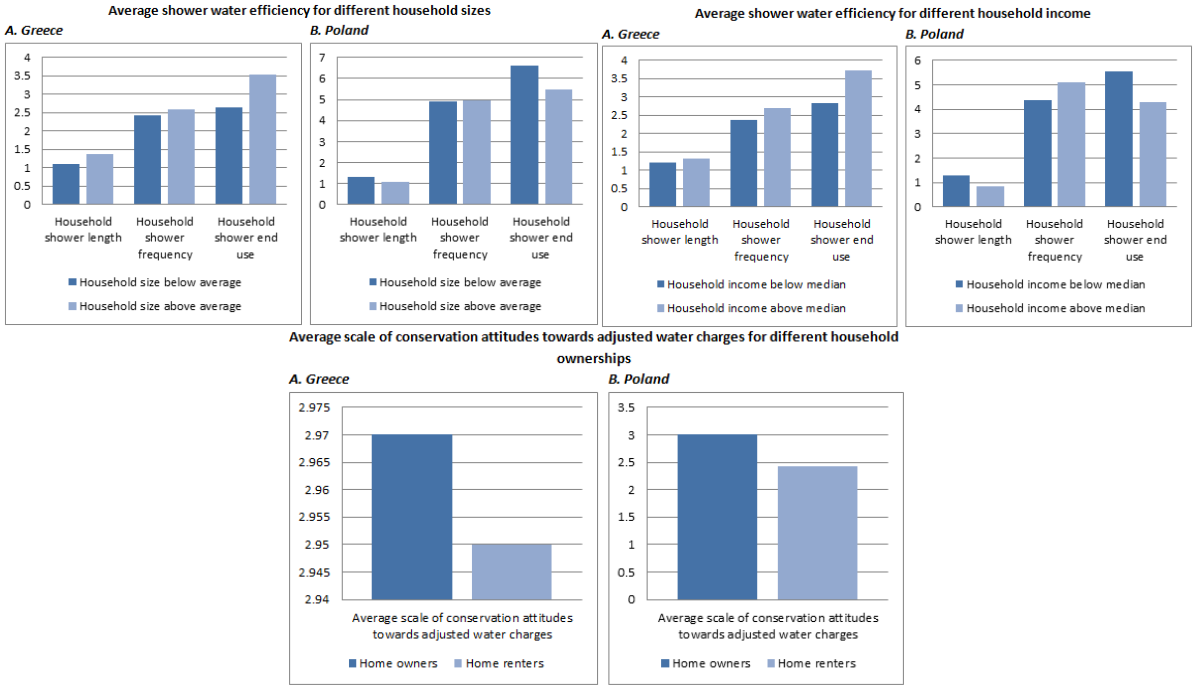


Fig. 8. Bivariate Analysis

5. Summary & Conclusion

This study offers insights into water consumption behavior at the household level. These insights will be used to inform how behavior intervention could be applied to domestic water consumers to promote water saving. A household water consumption survey was designed and administrated to the domestic water consumers in Greece and Poland. The data indicated that male adults and children took shorter showers than the female adults, and children took fewer showers per week than adults. Most household members take a shower during the evening and most have not tried to take shorter showers. The frequency of gardening during summer time was quite diverse and the irrigation systems for gardening were exclusively hand watering with only a small minority of respondents collecting rain water for gardening. Respondents gave low estimates of their personal water usage. Three major motivations for the efficient use of water at home are, to save water, to help the environment, and to save money. Most respondents report that they would be influenced by water conservation interventions such as information provision, mandatory water restrictions, and an adjusted water price. The impact of household size and income on water consumption was different for Greece and Poland. Similarly, the association between household ownership and responsiveness to changes in price was inconsistent between respondents from Greece and Poland. Future research should explore how these insights together with findings from other parts of the project [37][38] could illuminate and guide the behavior intervention design of household water consumption.

Acknowledgement

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