Determinants of Domestic Water Consumption: A Case Study in Northern Portugal

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Abstract

Efficient management of water resources, in both rural and urban areas, requires a full understanding of existing patterns of water use. Water demand management has been mainly focused on meeting agriculture water demand, whereas domestic water demand is largely ignored, and household water consumption has not been thoroughly researched in the majority of the countries. The World Health Organization (WHO) defined "domestic water" as water used for all domestic purposes including consumption, bathing and food preparation [1], [5]. Information regarding domestic water consumption is vital but is still lacking. The success of domestic water demand management strategies depends on identifying the determinants, and their interaction, that influence water consumption at a household scale [3].

This paper presents an empirical analysis of domestic water consumption and factors influencing water consumption in Vila Real County, in Northern Portugal. Through a field survey, the data were collected from December 2016 to January 2017 from 245 urban and rural households in 20 parishes of Vila Real County, and determinants influencing domestic water consumption are studied. Data analysis was performed by descriptive statistics, non-parametric tests and ordinal regression, namely by comparing the two groups (urban and rural households) [2], [4].

Keywords: Survey, Domestic Water Consumption, Non-parametric Tests Analysis, Ordinal Regression.

Introduction

At a time when scarce resources and climate change are great concerns, it is important to define water and energy efficiency strategies to minimize the harmful impact on the environment. Although water and energy systems have been treated independently, the consumption of water directly affects the consumption of energy, and therefore their consumptions are closely related. This is the so-called nexus water-energy, whose comprehensive study may lead to the identification of new solutions towards saving these resources. The purpose of this study is to characterize energy consumption associated with domestic water consumption in both rural and urban areas, by identifying the factors which influence these consumptions.

Methodology

A statistical methodology was established involving different areas such as sampling, descriptive statistics , statistics inference (non-parametric tests: Chi-square test of homogeneity, Mann-Whitney-Wilcoxon test) and ordinal regression models.

A questionnaire was prepared and data collection was carried out in person in each selected household. The collected data (via a survey with 74 questions divided into 6 groups) contained information on household members, housing construction / typology, energy consumption, water consumption, hygiene habits, etc.

- **Study area and sampling**

A total of 245 households: 110 urban households (45%) and 135 rural households (55%) in Vila Real County, in Northern Portugal. The main fieldwork took place between December 2016 and January 2017.

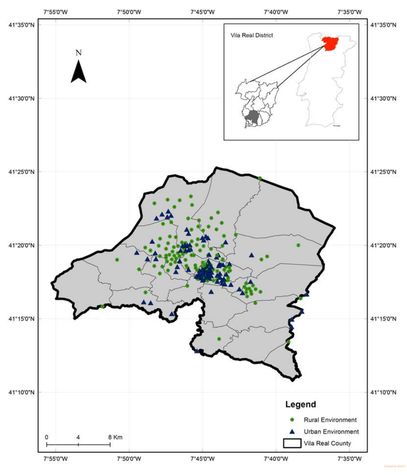
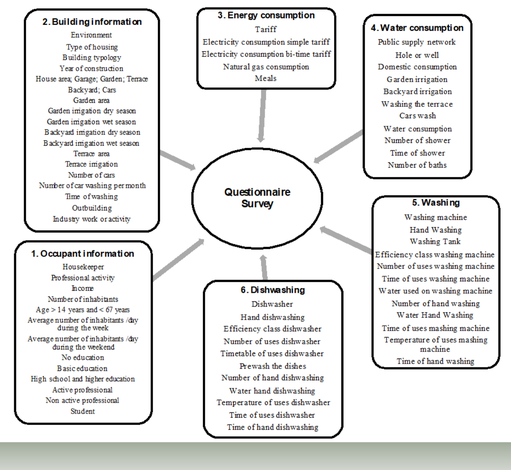


Figure 1: Sampling location

- **Study Variables**



Results

- **Energy Consumption**

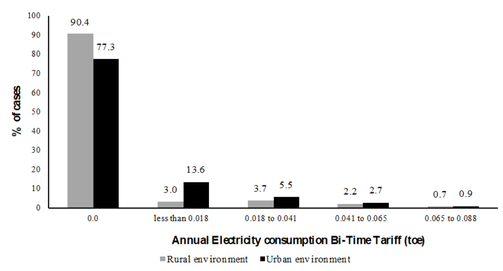


Figure 2: Description of households' annual electricity consumption with dual tariff

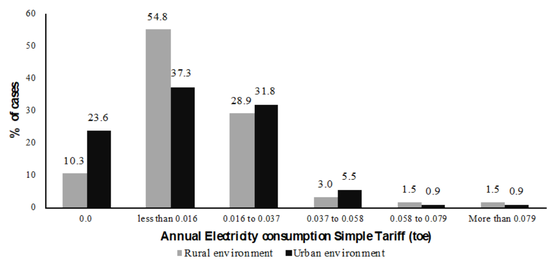


Figure 3: Description of households' annual electricity consumption with simple tariff

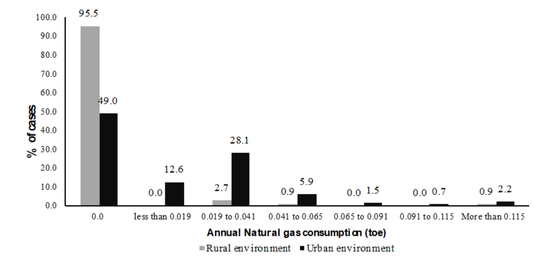


Figure 4: Description of households' annual natural gas consumption

- **Water Consumption**

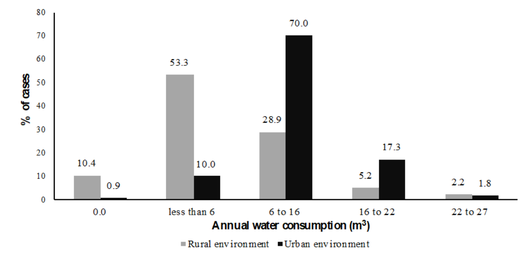


Figure 5: Description of households' annual water consumption from a public supply network

Table 1: Comparison of rural and urban environment distributions relating to "Tariff", "Manual washing", and "Dishwasher"

			Group I (Rural)	Group II (Urban)	*p**
Tariff	Simple tariff				
Total		Obs. Freq.	121 (89.6%)	84 (76.4%)	
Group I: 135		Standardized residuals	0.8	-0.8	
Group II: 110	Dual tariff				$p = 0.005$
		Obs. Freq.	14 (10.4%)	26 (23,6%)	
		Standardized residuals	-1.7	1.9	
Manual washing	Yes				
Total		Obs. Freq.	59 (43.7%)	22 (20.2%)	
Group I: 135		Standardized residuals	2.1	-2.4	
Groupo I: 110	No				$p < 0.001$
		Obs. Freq.	76 (56.3%)	87 (79.8%)	
		Standardized residuals	-1.5	1.7	
Dishwasher	Yes				
Total		Obs. Freq.	59 (43.7%)	70 (63.6%)	
Group I: 135		Standardized residuals	-1.4	1.6	
Group II: 110	No				$p = 0.002$
		Obs. Freq.	76 (56.3%)	40 (36.4%)	
		Standardized residuals	1.5	-1.7	

* Chi-square test

Table 2: Comparison of rural and urban environment distributions relating to "Average number of inhabitants per day during the week", "Number of meals per week", "Number of weekly showers", and "Duration of washing machine use"

	Test statistics	*p-value**
Average number of inhabitants per day during the week	U = 5358.5	$p < 0.001$
Number of meals per week	U = 3330.0	$p < 0.001$
Number of weekly showers	U = 6321.0	$p = 0.045$
Duration of washing machine use (min.)	U = 4896.0	$p = 0.007$

* Mann-Whitney-Wilcoxon test

Table 3: Variation in annual average water consumption and definition of Group A (dry season) and Group B (wet season)

	Water consumption											
	January	**February**	**March**	**April**	**May**	**June**	**July**	**August**	**September**	**October**	**November**	**December**
Average (Rural)	1.5	1.5	1.5	1.5	1.5	1.6	1.6	1.6	1.6	1.5	1.5	1.5
Average (Urban)	2.1	2.1	2.1	2.1	2.1	2.2	2.2	2.2	2.2	2.1	2.1	2.1
< 2 = [0;6]; ≥ 2 = [6;16]												
				B				A			B	

Table 4: Ordinal regression with dependent variable "Water consumption" for rural and urban environments and independent variable "Income"

	Water consumption m³	Estimate				Standard Deviation				Wald				*P-value**			
		Urban		Rural		Urban		Rural		Urban		Rural		Urban		Rural	
		Group A	Group B	Group A	Group B	Group A	Group B	Group A	Group B	Group A	Group B	Group A	Group B	Group A	Group B	Group A	Group B
	[0;6]	1.142	1.244	1.784	1.888	0.261	0.268	0.403	0.432	19.132	21.531	19.579	19.126	$p < 0.001$	$p < 0.001$	$p < 0.001$	$p < 0.001$
Limit	[6;16]	3.101	3.305	3.773	3.783	0.323	0.335	0.513	0.542	92.319	97.118	54.174	48.661	$p < 0.001$	$p < 0.001$	$p < 0.001$	$p < 0.001$
	[16;22]	4.631	4.173	4.590	4.910	0.438	0.530	0.612	0.720	111.869	95.191	56.294	46.541	$p < 0.001$	$p < 0.001$	$p < 0.001$	$p < 0.001$
Location	**Income**	0.473	0.457	0.544	0.474	0.087	0.088	0.144	0.152	29.314	26.768	14.218	9.689	$p < 0.001$	$p < 0.001$	$p < 0.001$	$p = 0.002$

Source: SPSS

Conclusions

A number of differences were found between rural and urban areas, with a higher consumption of both energy and water in the urban areas. In the urban areas, two types of energy are mainly used: natural gas and electricity, while in the rural areas electricity is predominant because most of the buildings are not equipped with natural gas installation. In the case of water, although the number of holes and wells is higher in the rural areas, almost all domestic water consumption comes from the public network, which reflects a high percentage of public equipment in these areas, as is the case in urban environments.

This study provides an important contribution to identifying the factors responsible for the differences between rural and urban areas in terms of water and energy consumption.

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