Science of the Total Environment 642 (2018) 421–435

Contents lists available at ScienceDirect

Science of the Total Environment

journal homepage: www.elsevier.com/locate/scitotenv

Which are the factors that may explain the differences in water and energy consumptions in urban and rural environments?

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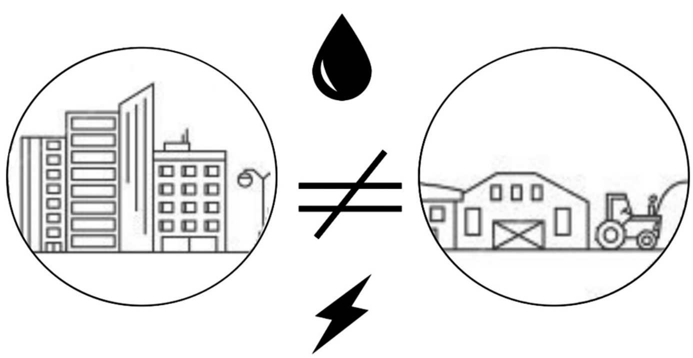
HIGHLIGHTS

- Factors that may support differences in water and energy consumptions in rural and urban areas
- Where found significant differences between rural and urban environments
- Descriptive data analysis and statistical inference (ST) are performed.
- Started with 80 variables after ST only 42 remained as differentiating factors of environments.

GRAPHICAL ABSTRACT



ARTICLE INFO

Article history:
Received 26 April 2018
Received in revised form 5 June 2018
Accepted 6 June 2018
Available online xxxx

Editor: D. Barcelo

Keywords:
Water and energy consumptions
Rural and urban environments
Survey
Statistical data analysis
Differentiating factors

ABSTRACT

Rural and urban environments present significant differences between water and energy consumptions. It is important to know, in detail, which factors related to the consumption of these two resources are different in both environments, once that will be those important to manage and discuss in order to improve its use efficiency and sustainability. This research work involves a survey whose aim is to find the factors that in rural and urban environments may justify the differences found in water and energy consumptions. Besides the collection of water and energy consumption data, this survey analyzed 80 variables (socio-demographic, economic, household characterization, among others), that were chosen among the bibliography as possible factors that should influence water and energy consumptions. After the survey application in rural and urban areas and the data statistical treatment, 42 variables remained as truly differentiating factors of rural and urban environments and so as possible determinants of water and energy consumptions. In order to achieve these objectives, a descriptive data analysis and statistical inference (Mann-Whitney-Wilcoxon test and the Chi-square test of homogeneity) were performed.
All the 42 differentiating variables that result from this study may be able to justify these differences, however this will not be presented in the paper and it is reserved for future work.

1. Introduction

Over the last twenty years, the European Commission has taken policy initiatives using the definitions of urban/rural spaces to affect resources. These definitions are mainly based on territorial characteristics. Some

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https://doi.org/10.1016/j.scitotenv.2018.06.062
0048-9697/

efforts have been made in order to distinguish urban areas from rural ones. For example, at the European level (Jonard et al., 2009):

- "45 minutes travel time to reach an urban centre with at least 50 000 inhabitants" has been selected to classify a commune as "remote" or "close to an urban centre";
- A commune is classified as an "open space" commune if at least 75% of its area is covered by forest, agricultural or natural areas. Otherwise, the commune is characterized as "closed space".

In 1994, the Organisation for Economic Co-operation and Development (OECD) established a simple territorial structure that identifies types of regions based on population density applied at two hierarchical levels (the local community level and the regional level). Given that at the European level there is no commonly-agreed definition of rural area, the OECD typology is considered as an easy and acceptable approach for identifying rural areas (Jonard et al., 2009).

While rural areas may develop randomly according to the natural ecosystem in a given region, urban spaces are normally properly planned, and built up according to a process called urbanization, in conformity with the criteria settled in a Municipal Master Plan (PDM). Sometimes, it is very difficult to delineate the frontiers between rural and urban areas, and the typology developed by the OCDE (2005) was operationalized for the European-level territory at the regional level (NUTS 3 or NUTS 2) using three categories of space: "predominantly urban areas", "median urban areas" and "predominantly rural areas." In Portugal, according to the National Statistical Institute (INE, 2015), an urban space is a statistical subsection that includes one of the following requirements:

1 – It has to be typified as "urban soil", according to the PDM criteria;

2 – It has to comprise a section with a population density of >500 inhabitants per km^2;

3 – It includes a place with a resident population of 5000 inhabitants or more.

A "predominantly rural area" is a statistical subsection typified as "non-urban land", according to the PDM criteria, and includes all of the following requirements:

1 – It was not previously included in the category of urban or semi-urban space;

2 – It has a population density equal to/or <100 inhabitants per km^2;

3 – It does not include a place with a resident population of 2000 inhabitants or more.

"Urban soil" is defined as land with recognized aptitude for the process of urbanization and construction, constituting its entire urban perimeter. The OCDE typology is exclusively based on population densities and is highly sensitive to the size of the geographical units. However, this may differ from country to country. In China, density requirement for an urban area is about 1500 persons/km^2. Two urban areas with less than two kilometres between them are considered an urban sector (Martin, 1992). In Australia, urban cities must include at least 1000 residents, with a population density of 200 persons/km^2, while in Canada an urban area is defined by a density of 400 persons/km^2 (ABS, 2017).

Unlike rural areas, urban settlements are defined by their progressive public facilities and high levels of attendance. Public facilities include water and energy services and it would be normal to expect that some differentiator factors of urban and rural environments will influence water and energy consumption. Urban customers usually pump, heat, wash and cook more than agricultural rural consumers that pump more water to irrigate fields and, consequently, it is expected that energy consumption in the two environments diverge widely (Arpke and Hutzler, 2006; Cheng, 2002). Rural water and energy demand management has been mainly focused on meeting the agricultural needs and policy-makers ignore the residential use.

Water used in the dwellings is of high quality and therefore a very expensive water. In addition to this situation, the consumption of water implies consumption of energy. Inside the dwellings, energy consumptions is also related to hot water consumption, and has very high costs and may have very serious consequences both in resource depletion and in pollution.

Knowledge of the factors that influence water consumption is very important to define strategies for its use and thus reduce costs, preserve the environment and public health. The different living habits of rural and urban populations, the different economic activities they develop and the type of housing and the surrounding garden or cultivated area, lead one to admit that the way they use water is also different. Thus, strategies for the use and reuse of water for rural and urban environments can be substantially different. In order to define water use strategies, that minimize consumption in the public network, that increase reuse, that reduce waste and that reduce energy associated consumption with water consumption, it is necessary to act in an knowledgeable way, and so the work here presented is absolutely important.

The study here presented has been developed as part of a research project called ENERWAT, financed by the Portuguese Science and Technology Foundation. One of the project's main aims is to settle the main differences between water and energy consumption in urban and rural households and to evaluate which factors contribute to these differences and how. The root of this project, and indeed the aim of this paper, that involves a survey application and data treatment is to find the factors that in rural and urban environments may justify the differences found in water and energy consumptions. Finding among all the studied factors the ones that differ between environments will show what factors should influence water and energy consumption differences.

2. Methodology

2.1. Study area and sampling

Vila Real County is located in Northern Portugal, with 378.80 km^2 divided between urban and rural land classification (Table 1). This county has 20 parishes (Fig. 1), 8 mainly urban (40%) and 12 mostly rural (60%), according to the National Statistical Institute (INE, 2015).

It has 327 inhabitants living in places classified as isolated, 21.899 inhabitants residing in places with <2000 habitants, and 29.624 inhabitants living in places with >2000 habitants (INE, 2015).

Vila Real is a medium-sized municipality integrated in the area of the Douro Valley in the interior North region and plays an important role in the equilibrium of the regional urban system. According to INE (2015), Vila Real urban population presents a relatively young age structure (ageing index of 121), and a medium level of education attainment (17% of population with tertiary education). It also presents a heavily tertiary economy (almost 80% of the employed population works in this activity sector) but with a relatively low average monthly earning (85% of the national average) (Matos et al., 2014).

Due to its physiographic location, in 2015 the county experienced temperatures (annual average temperature) between 10.1 and 16.9 °C, and precipitations between 127.8 mm in October and 0.5 mm in

Table 1
Land uses distribution in Vila Real County.

Land uses identified in the Municipal Master Plan (PDM)			
Urban land (ha)			Rural land (ha)
Total	Urbanized space	Expansion space	
4497.4	3157.7	336.4	33,380.8

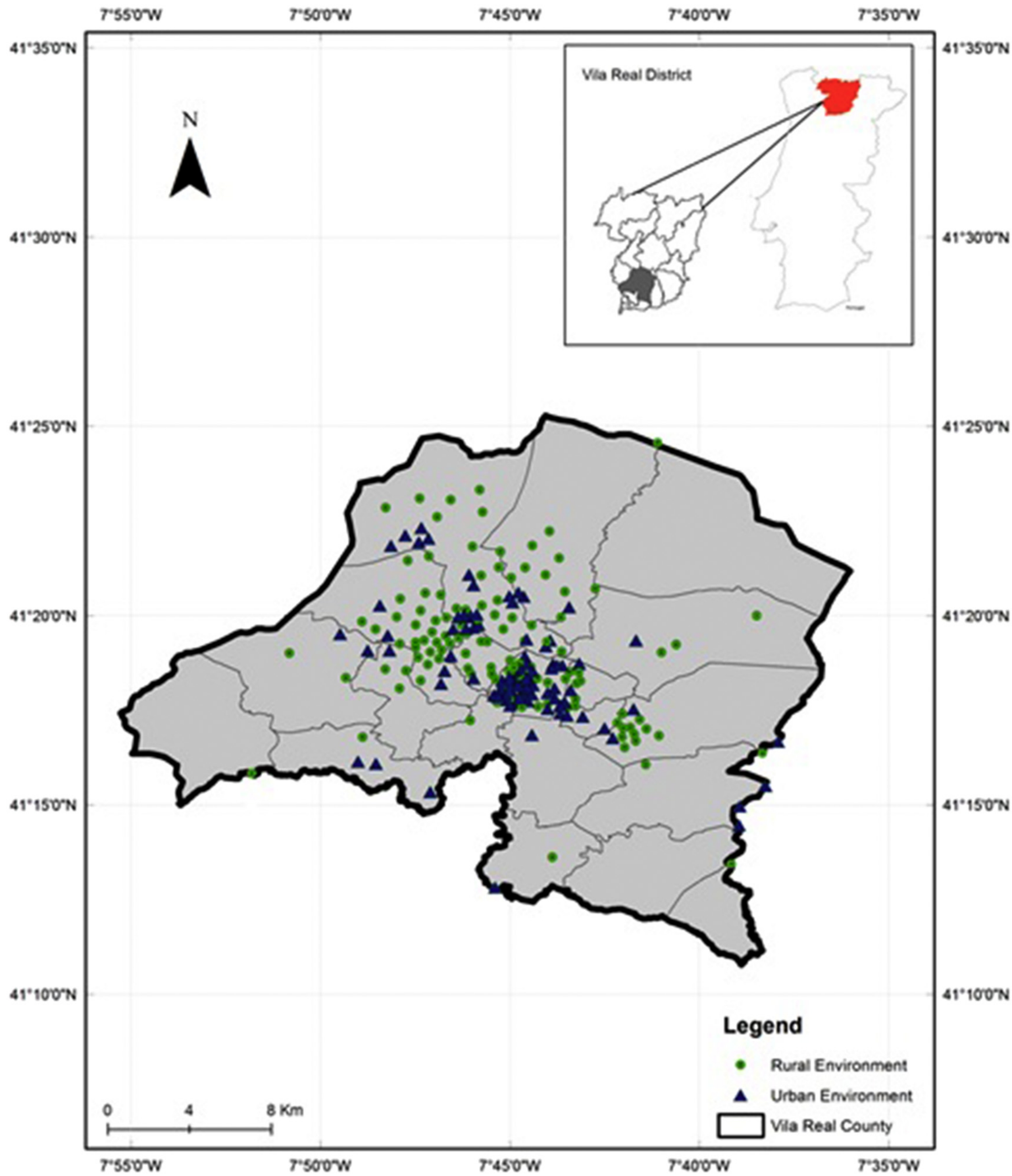

Fig. 1. Sampling location.

March, having had 259 days without precipitation in the same year (data from 2016, issued by the National Statistical Institute), indicating the dryness associated with this region.

In order to choose the houses to sample, some criteria (INE, 2015) were settled in order to classify the environment as rural or urban. So, for rural environment were considered the following sectors:

- Which belong to small villages inserted in the agricultural neighbourhood;
- Which had a population density equal to/or <100 inhabitants per km^2 at the community level;
- In which the inhabitants have full or part-time primary sector activity.

In relation to urban areas, the following criteria were considered:

- The households would have to be located in a medium/large agglomerate not inserted in the agricultural area;
- The area should have a population density of >100 inhabitants per km^2 at the community level;
- The inhabitants should have their professional activity in secondary and tertiary sectors.

A sample of households located in Vila Real County was selected. Each household was visited in order to fill out the survey on the spot, so that the researchers could explain relevant issues in person to ensure that the data was accurately collected. Only one person per family unit (independently of gender) answered to the survey, and participation was voluntary.

2.2. Survey design

The survey was designed using an online resource named “onlinepesquisa.com” and it was pretested in 40 households (via the pilot survey) in the study area, and additional modifications were made based on the results. A face-to-face interview in each household was later performed by two trained interviewers in order to tackle with inconclusive responses and other difficulties emerging from the interpretation of the survey items. The main fieldwork took place between December 2016 and January 2017.

The survey questions were defined in order to obtain information about family composition, household characterization, building information, water and energy consumption habits.

A total of 256 households were surveyed (N = 256). However, 11 surveys were discarded due to missing data. Sometimes the number of answers does not match with the number of surveys concluded. This have two explanations: on one hand, the survey contains questions with sub questions (the sub question is to be answered only if the answer to the main question enables a response in the sub question or due to important missing information), on the other hand, the survey has fields with the "no responses" field (the head of the household had no information to answer).

Hence, a total of 245 urban households (110 households, 45%) and rural (135 households, 55%) were considered for this research. Because the area is mostly rural, it was easier to perform more surveys in the rural areas, which explains this slight difference in the number of participants.

The final version of the survey integrates 74 questions grouped in six categories: occupant information, building information, energy consumption, water consumption, washing and dishwashing habits, Fig. 2. The questions were elaborated based on the literature review carried out (Binks et al., 2016; Basu et al., 2017; Haziq and Panezai, 2017; Keshavarzi et al., 2006; Singh and Turkiya, 2013; Hu et al., 2017; Martinez-Santos, 2017; Fan et al., 2017).

Table 2 presents the quantitative (continuous and discrete) and qualitative (categorical/nominal and ordinal) variables that were considered as possible differentiating factors of rural and urban environments. Table 2 also presents the description of the categories of the qualitative variables.

2.3. Data analysis

Several statistical analyses were performed to analyze and present the data. The statistical package IBM SPSS23.0 was used for data entry and analysis. Special emphasis was given to the exploratory data analysis. Descriptive statistics (absolute and relative frequency, mean, mode, range, and standard deviation) of the variables across rural and urban environments were used to summarize the survey results and to characterize water and energy consumption in rural and urban households. Considering the nature of the dataset, non-parametric hypothesis tests were applied in order to compare the variables collected in rural and urban households, and to distinguish both environments.

Parametric tests are based on quantitative or even dichotomous measures (proportions), and the use of this type of test requires continuous variables, usually the assumptions of Normal distribution, and homogeneity of variance. In case of failure of at least one of these requirements for the application of these tests, non-parametric tests should be used. Non-parametric tests, when compared with parametric tests, can also be applied to qualitative (categorical/nominal and

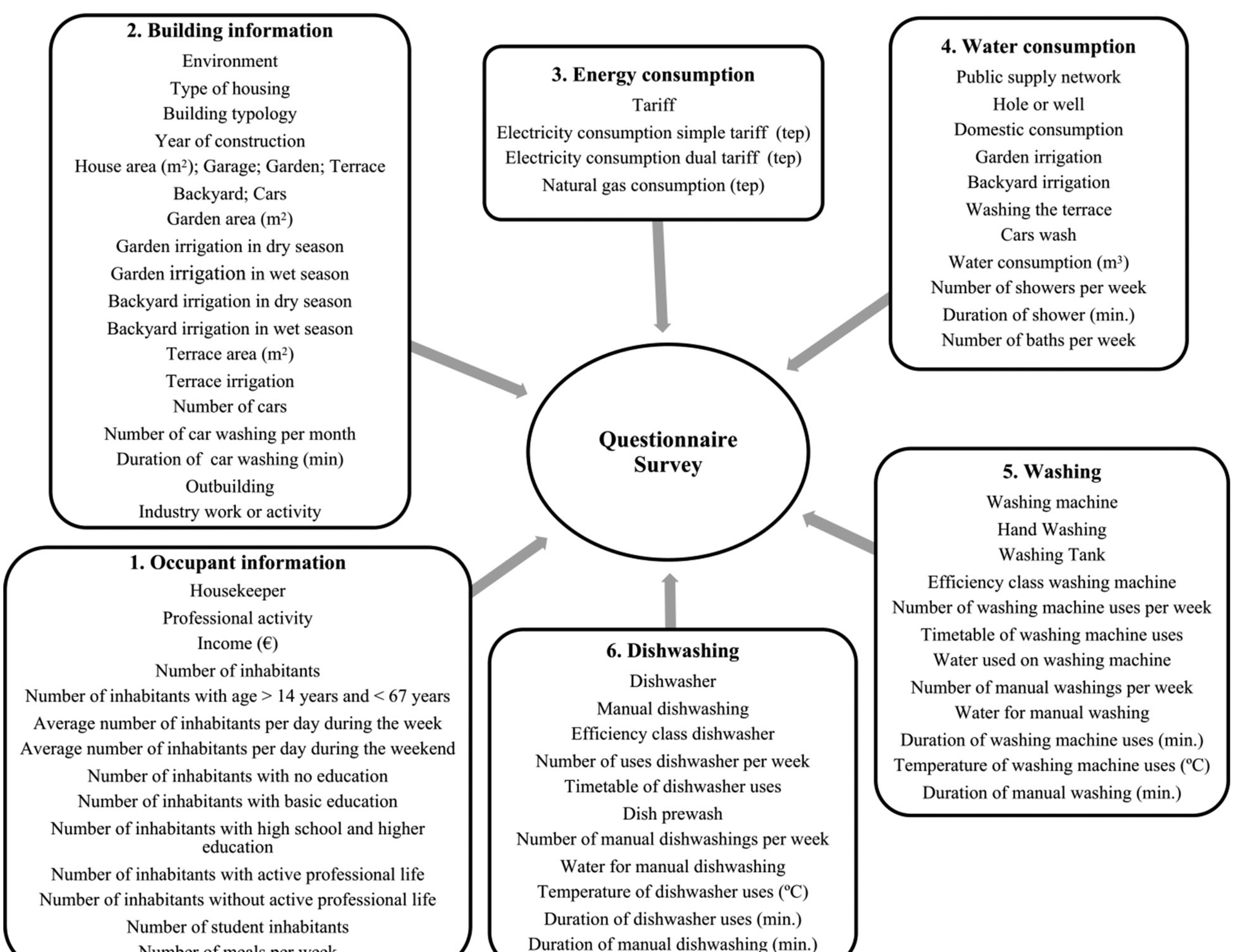

Fig. 2. Categories integrated in the survey.

Table 2
Description of household variables collected.

Variable definition	
1. Occupant information	
Qualitative variables	
Housekeeper	1 = yes; 2 = no
Professional activity	1 = with agricultural, domestic and vineyard activities 2 = without agricultural, domestic and vineyard activities
Income (€)	1 = less than €500 2 = between €500 and €999 3 = between €1000 and €1999 4 = between €2000 and €3000 5 = more than €3000
Quantitative variables	
Number of inhabitants	
Number of inhabitants with age >14 years and <67 years	
Average number of inhabitants per day during the week	
Average number of inhabitants per day during the weekend	
Number of inhabitants with no education	
Number of inhabitants with basic education	
Number of inhabitants with high school and higher education	
Number of inhabitants with active professional life	
Number of inhabitants without active professional life	
Number of student inhabitants	
Number of meals per week	
2. Building information	
Qualitative variables	
Environment	0 = rural; 1 = urban
Type of housing	1 = multidwelling unit (MDU) 2 = single family dwelling (SFD), isolated 3 = single family dwelling (SFD), detached
Year of construction	1 = until 1990 2 = between 1990 and 2006 3 = between 2006 and 2013
House area (m^2)	1 = less than 100 m^2 2 = between 100 m^2 and 200 m^2 3 = between 200 m^2 and 300 m^2 4 = more than 300 m^2
Building typology	1 = house; 2 = apartment
Garage	1 = yes; 2 = no
Garden	1 = yes; 2 = no
Terrace	1 = yes; 2 = no
Backyard	1 = yes; 2 = no
Cars	1 = yes; 2 = no
Garden area (m^2)	1 = less than 100 m^2; 2 = more than 100 m^2
Garden irrigation in dry season	1 = yes; 2 = no
Garden irrigation in wet season	1 = yes; 2 = no
Backyard irrigation in dry season	1 = yes; 2 = no
Backyard irrigation in wet season	1 = yes; 2 = no
Terrace area (m^2)	1 = less than 10 m^2 2 = between 10 and 20 m^2 3 = more than 20 m^2
Terrace irrigation	1 = yes; 2 = no
Number of cars	1 = 1 2 = 2 3 = 3 4 = 4 5 = >4
Number of car washings per month	1 = 0; 2 = 1; 3 = 2 or more
Duration of car washing (min)	1 = less than 15 min 2 = more than 15 min 3 = 2 or more
Outbuilding	1 = yes; 2 = no
Industry work or activity	1 = yes; 2 = no
3. Energy consumption	
Qualitative variables	
Tariff	1 = simple tariff; 2 = dual tariff
Electricity consumption simple tariff (toe)	1 = <0.016 toe 2 = between 0.016 toe and 0.037 toe 3 = between 0.037 toe and 0.058 toe 4 = between 0.058 toe and 0.079 toe 5 = more than 0.079 toe
Electricity consumption dual tariff (toe)	1 = less than 0.018 toe 2 = between 0.018 toe and 0.041 toe 3 = between 0.041 toe and 0.065 toe 4 = between 0.065 toe and 0.088 toe 5 = more than 0.088 toe
Natural gas consumption (toe)	1 = less than 0.019 toe 2 = between 0.019 toe and 0.041 toe 3 = between 0.041 toe and 0.065 toe 4 = between 0.065 toe and 0.091 ep 5 = between 0.091 toe and 0.115 toe 6 = more than 0.115 toe
4. Water consumption	
Qualitative variables	
Public supply network	1 = yes; 2 = no
Water hole or well	1 = yes; 2 = no
Domestic consumption	1 = public supply network; 2 = hole or well
Garden irrigation	1 = public supply network; 2 = hole or well
Backyard irrigation	1 = public supply network; 2 = hole or well
Terrace washing	1 = public supply network; 2 = hole or well
Car washing	1 = public supply network; 2 = hole or well
Water consumption (m^3)	1 = less than 6 m^3 2 = between 6 m^3 and 16 m^3 3 = between 16 m^3 and 22 m^3 4 = between 22 m^3 and 27 m^3 5 = between 27 m^3 and 34 m^3 6 = more than 34 m^3
Quantitative variables	
Number of showers per week	
Duration of shower (min)	
Number of baths per week	
5. Washing	
Qualitative variables	
Washing machine	1 = yes; 2 = no
Clothes manual washing	1 = yes; 2 = no
Washing tank	1 = yes; 2 = no
Efficiency class washing machine	1 = A+++ 2 = A++ 3 = A+ 4 = A 5 = B
Number of washing machine uses per week	1 = 0 2 = 1 to 3 3 = 4 to 6 4 = 7 to 10 5 = more than 10
Timetable of washing machine uses	1 = 8:00 am–11:59 am 2 = 12:00 am–07:59 pm 3 = 08:00 pm–7:59 am 4 = random
Water used in the washing machine	1 = cold water 2 = warm water 3 = cold and warm water
Number of manual washings per week	1 = 0; 2 = 1 3 = more than 1
Water for manual washing	1 = cold water 2 = cold and warm water
Quantitative variables	
Duration of washing machine uses (min)	
Temperature of washing machine uses (°C)	
Duration of manual washing (min)	
6. Dishwashing	
Qualitative variables	
Dishwasher	1 = yes; 2 = no
Manual dishwashing	1 = yes; 2 = no
Efficiency class dishwasher	1 = A+++ 2 = A++ 3 = A+ 4 = A 5 = B
Number of dishwasher uses per week	1 = 0 2 = 1 to 3 3 = 4 to 6 4 = more than 7
Timetable of dishwasher uses	1 = 8:00 am–11:59 am 2 = 12:00 am–07:59 pm 3 = 08:00 pm–7:59 am

Table 2 (*continued*)

Variable definition	
	4 = random
Dish prewash	1 = no
	2 = yes, manually
	3 = yes, in the machine
Number of manual dishwashing per week	1 = 0
	2 = 1 to 3
	3 = 4 to 6
	4 = 7 to 10
	5 = more than 10
Water for manual dishwashing	1 = cold water
	2 = cold and warm water
Quantitative variables	
Temperature of dishwasher uses (°C)	
Duration of dishwasher uses (min)	
Duration of manual dishwashing (min)	

ordinal) variables, they require fewer assumptions for distributions, they are very useful for the analysis of large samples where parametric assumptions do not occur, and also for very small samples (Conover, 1998).

In this study, due to the nature of the observed variables and respective distributions, two non-parametric hypothesis tests were performed: the Mann-Whitney-Wilcoxon test and the Chi-square test of homogeneity.

The non-parametric Mann-Whitney-Wilcoxon hypothesis test is applied when comparing outcomes between two independent populations, in order to detect if the distributions are equal or to detect changes in location (median); it is important to note that the null hypothesis is the same for both. This test is used as an alternative to the t (parametric) test for the equality of two means of independent samples (for quantitative variables), when it cannot be applied due to violation of the assumptions, namely that of normality or when there is no information about the theoretical distributions. The non-parametric Chi-square test of homogeneity is applied to a single qualitative (categorical or ordinal) variable from two or more different populations. It is used to determine whether frequency counts are identically distributed across different populations, i.e. for testing whether two or more multinomial distributions are equal (Higgins, 2004).

In this study, two populations are considered: rural and urban populations.

The results from the statistical tests were evaluated using the 5% significance level as the threshold for distinguishing between "not statistically significant" and the opposite. It is worth stressing that the results of some of these tests will not be reported here.

3. Descriptive statistics analysis and non-parametric hypothesis tests

In this section, it will be presented the results of the descriptive analysis and the results of the data comparison between the two groups through the analysis of the statistical non-parametric tests performance.

Descriptive statistics of the variables are presented in Tables 3 and 4 for quantitative and qualitative variables, respectively, in rural and urban regions. These variables/factors were statistically significant in the differentiation of the behavior of their distributions in the rural (Group I (R)) and urban (Group II (U)) environments analyzed, as a result of the application of non-parametric hypothesis tests. The results of the performed non-parametric tests, where the differences between the two environments are highlighted, are presented from Tables 5 to 11.

3.1. Occupant information

Table 5 indicates that the majority of the households in both studied environments doesn't have "Housekeeper", the two groups assumed "no housekeeper" as modal category, with 94.1% in group I (Rural) and 79.1% in group II (Urban). Also, at 0.05 significance level, there is enough statistical evidence to state that the frequency counts of "Housekeeper" are not identically distributed across the two environments (test statistic $\chi 2\ (1) = 12.312$, p-value < 0.001), i.e. environment influences the multinomial distributions of "Housekeeper". As expected, and although the results presented, in the urban environment is more common to have housekeeper than in the rural one.

The majority of professional activity of the household head is associated to "No agricultural, domestic and vineyard activities" in both environments (rural and urban), with 71.1% in Group I (Rural) and 97.3% in Group II (Urban).

It was found that the household head with professional activity "No/With agricultural, domestic and vineyard activities" in rural areas distributes differently from those in urban areas ($\chi 2\ (1) = 29.206$, p-value < 0.001), i.e., environment influences the multinomial distributions of "No/with agricultural, domestic and vineyard activities". It would be expected that in rural areas the main professional activity would be the "agriculture or domestic activity" and, as this region is located in Douro region, the activity "vineyard" would have a great percentages of responses. The obtained results can be explained by the geographical proximity to Vila Real urban area and so, the main activities of the households are not linked to the primary sector. Although there is a slight difference between rural and urban in this variable and the main number of responses as "with agricultural…" belongs to the rural environment (39 to 3 in urban environment-Table 4).

Table 3
Description of household characteristics using quantitative (continuous and discrete) variables.

Variable definition	N		Range		Mean		Mode		Std. dev.	
	R	U	R	U	R	U	R	U	R	U
Average number of inhabitants per day during the week	135	110	1–6	0–4	2.2	1.70	2	1	0.91	0.91
Average number of inhabitants per day during the weekend	135	110	1–7	0–6	2.8	2.20	2	2	1.19	1.32
Number of inhabitants with no education	135	110	0–2	0–1	0.1	0.03	0	0	0.39	0.16
Number of inhabitants with basic education	135	110	0–6	0–6	1.8	0.70	2	0	1.09	1.03
Number of inhabitants with high school and higher education	135	110	0–4	0–5	1.0	1.90	0	2	1.04	0.98
Number of inhabitants with active professional life	135	110	0–5	0–4	1.2	1.50	0	2	1.18	0.81
Number of inhabitants without active professional life	135	110	0–4	0–3	1.4	0.60	2	0	1.05	0.80
Number of meals per week	135	110	2–24	0–45	16.7	11.20	21	14	5.68	6.45
Number of showers per week	135	110	1–50	3–50	13.9	15.90	4	14	9.69	9.00
Number of baths per week	135	110	0–10	0–50	0.3	1.70	0	0	1.21	6.23
Duration of washing machine uses (min)	121	102	15–240	25–180	86.8	78.10	90	60	32.07	37.45
Duration of manual washing (min)	58	22	5–60	5–30	22.9	12.10	20	10	11.43	5.91
Temperature of dishwasher uses (°C)	50	60	30–80	10–100	45.4	53.50	40	60	12.16	15.60
Duration of dishwasher uses (min)	56	70	30–180	29–185	65.5	82.50	60	60	38.01	42.62
Duration of manual dishwashing (min)	120	89	5–30	2–40	16.3	13.40	20	15	5.31	6.37

Table 4
Description of household characteristics using qualitative (categorical and ordinal) variables.

Variable definition	Categories	Frequency		N	
		R	U	R	U
Housekeeper	1 = yes	8 (5.9%)	23 (20.9%)	135	110
	2 = no	127 (94.1%)	87 (79.1%)		
Professional activity	1 = with agricultural, domestic and vineyard activities	39 (28.9%)	3 (2.7%)	135	110
	2 = no agricultural, domestic and vineyard activities	96 (71.1%)	107 (97.3%)		
Income (€)	1 = less than €500	22 (16.3%)	2 (1.8%)	135	110
	2 = between €500 and €999	60 (44.4%)	26 (23.6%)		
	3 = between €1000 and €1999	37 (27.4%)	51 (46.4%)		
	4 = between €2000 and €3000	13 (9.6%)	19 (17.3%)		
	5 = more than 3000 €	3 (2.2%)	12 (10.9%)		
Type of housing	1 = multi-family housing	5 (3.7%)	77 (70.0%)	135	110
	2 = single family dwelling, isolated	94 (69.6%)	16 (14.5%)		
	3 = single family dwelling, twinned	36 (26.7%)	17 (15.5%)		
Year of construction	1 = until 1990	86 (64.7%)	39 (53.2%)	133	102
	2 = between 1990 and 2006	40 (30.1%)	49 (48.0%)		
	3 = between 2006 and 2013	7 (5.3%)	14 (13.7%)		
House area (m^2)	1 = less than 100 m^2	27 (22.1%)	28 (29.2%)	122	96
	2 = between 100 m^2 and 200 m^2	48 (39.3%)	47 (49.0%)		
	3 = between 200 m^2 and 300 m^2	27 (22.1%)	13 (13.5%)		
	4 = more than 300 m^2	20 (16.4%)	8 (8.3%)		
Building typology	1 = house	130 (96.3%)	32 (29.1%)	135	110
	2 = apartment	5 (3.7%)	78 (70.9%)		
Garden	1 = yes	77 (57.0%)	29 (26.4%)	135	110
	2 = no	58 (43.0%)	81 (73.6%)		
Terrace	1 = yes	86 (63.7%)	57 (51.8%)	135	110
	2 = no	49 (36.3%)	53 (48.2%)		
Backyard	1 = yes	68 (50.4%)	13 (11.8%)	135	110
	2 = no	67 (49.6%)	97 (88.2%)		
Terrace area (m^2)	1 = less than 10 m^2	27 (31.0%)	28 (49.1%)	87	57
	2 = between 10 and 20 m^2	40 (46.0%)	18 (31.6%)		
	3 = more than 20 m^2	20 (23.0%)	11 (19.3%)		
Number of car washings per month	1 = 0	38 (39.2%)	62 (79.5%)	97	78
	2 = 1	46 (47.4%)	8 (10.3%)		
	3 = 2 or more	13 (13.4%)	8 (10.3%)		
Tariff	1 = simple tariff	121 (89.6%)	84 (76.4%)	135	110
	2 = dual tariff	14 (10.4%)	26 (23.6%)		
Public supply network	1 = yes	121 (89.6%)	110 (100%)	135	110
	2 = no	14 (10.4%)	0 (0.0%)		
Water hole or well	1 = yes	42 (31.1%)	8 (7.3%)	135	110
	2 = no	93 (68.9%)	102 (92.7%)		
Domestic consumption	1 = public supply network	118 (88.7%)	110 (100%)	133	110
	2 = hole or well	15 (11.3%)	0 (0.0%)		
Garden irrigation	1 = public supply network	23 (40.4%)	17 (68.0%)	57	25
	2 = hole or well	34 (59.6%)	8 (32.0%)		
Terrace washing	1 = public supply network	24 (44.4%)	35 (79.5%)	54	44
	2 = hole or well	30 (55.6%)	9 (20.5%)		
Manual washing	1 = yes	59 (43.7%)	22 (20.2%)	135	109
	2 = no	76 (56.3%)	87 (79.8%)		
Clothes manual washing	1 = yes	36 (26.7%)	18 (16.4%)	135	110
	2 = no	99 (73.3%)	92 (83.6%)		
Efficiency class washing machine	1 = A+++	6 (5.0%)	16 (16.0%)	119	100
	2 = A++	12 (10.1%)	40 (40.0%)		
	3 = A+	64 (53.8%)	31 (31.0%)		
	4 = A	31 (26.1%)	10 (10.0%)		
	5 = B	6 (5.0%)	3 (3.0%)		
Timetable of washing machine uses	1 = 08:00 am–11:59 am	7 (5.7%)	8 (7.7%)	122	104
	2 = 12:00 am–07:59 pm	6 (4.9%)	8 (6.4%)		
	3 = 08:00 pm–07:59 am	15 (12.3%)	32 (30.8%)		
	4 = random	94 (77.0%)	56 (53.8%)		
Water for manual washing	1 = cold water	49 (83.1%)	5 (23.8%)	59	21
	2 = cold and warm water	10 (16.9%)	16 (76.2%)		
Dishwasher	1 = yes	59 (43.7%)	70 (63.6%)	135	110
	2 = no	76 (56.3%)	40 (36.4%)		
Manual dishwashing	1 = yes	122 (90.4%)	90 (81.8%)	135	110
	2 = no	13 (9.6%)	20 (18.2%)		
Number of manual dishwashings	1 = 0	2 (1.7%)	0 (0.0%)	121	89
	2 = 1 to 3	14 (11.6%)	12 (13.5%)		
	3 = 4 to 6	9 (7.4%)	16 (18.0%)		
	4 = 7 to 10	65 (53.7%)	28 (31.5%)		
	5 = more than 10	31 (25.6%)	33 (37.1%)		
Manual washing use of water	1 = cold water	50 (41.7%)	24 (27.0%)	120	89
	2 = cold and warm water	70 (58.3%)	65 (73.0%)		

Table 5
Comparison of rural and urban environment distributions relating to "Housekeeper", "Professional activity", and "Income".

		Group I (Rural)	Group II (Urban)	p-Value[a]
Housekeeper	Yes			$p < 0.001$
Total	Obs. Freq.	8 (5.9%)	23 (20.9%)	
Group I: 135	Standardized residuals	−2.2	2.4	
Group II: 110	No			
	Obs. Freq.	127 (94.1%)	87 (79.1%)	
	Standardized residuals	0.8	−0.9	
Professional activity	With agricultural, domestic and vineyard activities			$p < 0.001$
Total	Obs. Freq.	39 (28.9%)	3 (2.7%)	
Group I: 135	Standardized residuals	3.3	−3.7	
Group II: 110	No agricultural, domestic and vineyard activities			
	Obs. Freq.	96 (71.1%)	107 (97.3%)	
	Standardized residuals	−1.5	1.7	
Income	Less than €500			$p < 0.001$
Total	Obs. Freq.	22 (16.3%)	2 (1.8%)	
Group I: 135	Standardized residuals	2.4	−2.7	
Group II: 110	Between €500 and €999			
	Obs. Freq.	60 (44.4%)	26 (23.6%)	
	Standardized residuals	1.8	−2	
	Between €1000 and €1999			
	Obs. Freq.	37 (27.4%)	51 (46.4%)	
	Standardized residuals	−1.7	1.8	
	Between €2000 and €3000			
	Obs. Freq.	13 (9.6%)	19 (17.3%)	
	Residuals standardized	−1.1	1.2	
	More than €3000			
	Obs. Freq.	3 (2.2%)	12 (10.9%)	
	Standardized residuals	−1.8	2	

[a] Chi-square test.

Table 6
Comparison of rural and urban environment distributions relating to "Type of housing", "Year of construction", "House area", "Building typology", and "Garden".

		Group I (Rural)	Group II (Urban)	p-Value*
Type of housing	MDU			$p < 0.001$
Total	Obs. Freq.	5 (3.7%)	77 (70.0%)	
Group I: 135	Standardized residuals	−6.0	6.6	
Group II: 110	SFU, isolated			
	Obs. Freq.	94 (69.6%)	16 (14.5%)	
	Standardized residuals	4.3	−4.8	
	SFU, twinned			
	Obs. Freq.	36 (26.7%)	17 (15.5%)	
	Standardized residuals	1.3	−1.4	
Year of construction	Until 1990			$p < 0.001$
	Obs. Freq.	86 (64.7%)	39 (53.2%)	
Total	Standardized residuals	1.8	−2.1	
Group I: 133				
Group II: 102	Between 1990 and 2006			
	Obs. Freq.	40 (30.1%)	49 (48.0%)	
	Standardized residuals	−1.5	1.7	
	Between 2006 and 2013			
	Obs. Freq.	7 (5.3%)	14 (13.7%)	
	Standardized residuals	−1.4	1.6	
House area	Less than 100 m^2			$p^a = 0.070$
Total	Obs. Freq.	27 (22.1%)	28 (29.2%)	
Group I: 122	Standardized residuals	−0.7	0.8	
Group II: 96	Between 100 m^2 and 200 m^2			
	Obs. Freq.	48 (39.3%)	47 (49.0%)	
	Standardized residuals	−0.7	0.8	
	Between 200 m^2 and 300 m^2			
	Freq Obs	27 (22.1%)	13 (13.5%)	
	Standardized residuals	1.0	−1.1	
	More than 300 m^2			
	Freq Obs	20 (16.4%)	8 (8.3%)	
	Standardized residuals	1.1	−1.2	
Building typology	House			$p < 0.001$
	Freq Obs	130 (96.3%)	32 (29.1%)	
Total	Standardized residuals	4.3	−4.8	
Group I: 135				
Group II: 110	Apartment			
	Freq Obs	5 (3.7%)	78 (70.9%)	
	Standardized residuals	−6.0	6.7	
Garden	Yes			$p < 0.001$
Total	Freq Obs	77 (57.0%)	29 (26.4%)	
Group I: 135	Standardized residuals	2.4	−2.7	
Group II: 110	No			
	Freq Obs	58 (43.0%)	81 (73.6%)	
	Standardized residuals	−2.1	2.4	

* Chi-square test.
[a] Significant at the 0.10 level.

Considering household incomes, it is observed from Table 5 that the "Less than €500" category is primarily responsible for the non-homogeneity of the proportion of elements in the two environments in the different categories: 16.3% of the rural households earn "Less than €500" versus 1.8% corresponding to two urban households ($\chi2$ (4) = 36.692, p-value < 0.001). In fact, the "Less than €500" category presents a proportion of rural environment households larger than the expected frequency. This discrepancy remains, although a little less pronounced in the "Between €500 and €999" category, reversing completely when is analyzed the data from categories "Between €1000 and €1999", "Between €2000 and €3000", and "More than €3000". The observed frequency of Group I is lower than the expected frequency.

The data analysis indicates that household incomes are lower in a rural environment: about half of the respondents (44.4%) earn "Between €500 and €999", whereas almost half of respondents (46.4%) in an urban environment earn "Between €1000 and €1999". Only 2.2% of the household income in a rural environment is "More than €3000", but 10.9% in an urban environment.

The average number of inhabitants per day during the week in the housing ranges from 1 to 6 (with a mean of 2.2) in rural areas, and this value is higher than the urban average, which is 0 to 4 (with a mean of 1.7) (Table 3), although the data dispersion in both environments is similar (both distributions with a standard deviation 0.91: there is a variation of about one inhabitant per day around the mean). Note that in Group I (Rural) the most frequent number of inhabitants per day during the week is 2 inhabitants, while in Group II (Urban) is only 1 people (mode = 2 and mode = 1). In order to examine the behavior of the average number of inhabitants per day during the week by environment, a Mann-Whitney-Wilcoxon test was computed. There was statistically significant evidence at $\alpha = 0.05$ to conclude that the two population distributions (rural and urban) of the average number of inhabitants per day during the week are not equal (p-value < 0.001).

The average number of inhabitants per day during the weekend ranges between 1 and 7 (with a mean of 2.8, about 3 inhabitants) in a rural environment, and between 0 and 6 (with a mean of 2.2, about 2 inhabitants) in an urban environment. There were found significant differences (medians) in the distributions of the average number of inhabitants per day during the weekend in rural and urban areas (p-value = 0.002).

Table 7
Comparison of rural and urban environment distributions relating to "Terrace", "Backyard", "Terrace area", and "Number of car washings per month".

		Group I (Rural)	Group II (Urban)	p-Value[*]
Terrace	Yes			$p^a =$ 0.060
Total	Obs. Freq.	86 (63.7%)	57 (51.8%)	
Group I: 135				
Group II: 110	Standardized residuals	0.8	−0.9	
	No			
	Obs. Freq.	49 (36.3%)	53 (48.2%)	
	Standardized residuals	−1.0	1.1	
Backyard	Yes			$p <$ 0.001
Total	Obs. Freq.	68 (50.4%)	13 (11.8%)	
Group I: 135				
Group II: 110	Standardized residuals	3.5	−3.9	
	No			
	Obs. Freq.	67 (49.6%)	97 (88.2%)	
	Standardized residuals	−2.5	2.7	
Terrace area	Less than 10 m^2			$p^a =$ 0.085
Total	Obs. Freq.	27 (31.0%)	28 (49.1%)	
Group I: 87				
Group II: 57	Standardized residuals	−1.1	1.3	
	Between 10 and 20 m^2			
	Obs. Freq.	40 (46.0%)	18 (31.6%)	
	Standardized residuals	0.8	−1.0	
	More than 20 m^2			
	Obs. Freq.	20 (23.0%)	11 (19.3%)	
	Standardized residuals	0.3	−0.4	
Number of car washings per month	0			$p <$ 0.001
Total	Obs. Freq.	38 (39.2%)	62 (79.5%)	
Group I: 97				
Group II: 78	Standardized residuals	−2.3	2.6	
	1			
	Obs. Freq.	46 (47.4%)	8 (10.3%)	
	Standardized residuals	2.9	−3.3	
	2 or more			
	Obs. Freq.	13 (13.4%)	8 (10.3%)	
	Standardized residuals	0.4	−0.4	

[*] Chi-square test.
[a] Significant at the 0.10 level.

Although the dispersion in group I (Rural) and in group II (Urban) is practically the same (standard deviation of 1.19 and 1.32 inhabitants), the average number of inhabitants per day during the weekend varies by about one person from the mean.

Table 8
Comparison of rural and urban environment distributions relating to "Tariff".

		Group I (Rural)	Group II (Urban)	p-Value[a]
Tariff	Simple tariff			$p = 0.005$
Total	Obs. Freq.	121 (89.6%)	84 (76.4%)	
Group I: 135	Standardized residuals	0.8	−0.8	
Group II: 110	Dual tariff			
	Obs. Freq.	14 (10.4%)	26 (23.6%)	
	Standardized residuals	−1.7	1.9	

[a] Chi-square test.

Table 9
Comparison of rural and urban environment distributions relating to "Public supply network", "Water hole or well", "Domestic consumption", "Garden irrigation", and "Terrace washing".

		Group I (Rural)	Group II (Urban)	p-Value[a]
Public supply network	Yes			$p =$ 0.001
Total	Obs. Freq.	121 (89.6%)	110 (100%)	
Group I: 135	Standardized residuals	−0.6	0.6	
Group II: 110				
	No			
	Obs. Freq.	14 (10.4%)	0 (0.0%)	
	Standardized residuals	2.3	−2.5	
Water hole or well	Yes			$p < 0.001$
Total	Obs. Freq.	42 (31.1%)	8 (7.3%)	
Group I: 135	Standardized residuals	2.8	−3.0	
Group II: 110				
	No			
	Obs. Freq.	93 (68.9%)	102 (92.7%)	
	Standardized residuals	−1.4	1.5	
Domestic consumption	Public supply network			$p < 0.001$
Total	Obs. Freq.	118 (88,7%)	110 (100%)	
Group I: 133				
Group II: 110	Standardized residuals	−0.6	0.7	
	Water hole or well			
	Obs. Freq.	15 (11.3%)	0 (0.0%)	
	Standardized residuals	2.4	−2.6	
Garden irrigation	Public supply network			$p =$ 0.021
Total				
Group I: 57	Freq Obs	23 (40.4%)	17 (68%)	
Group II: 25	Standardized residuals	−0.9	1.4	
	Water hole or well			
	Obs. Freq.	34 (59.6%)	8 (32%)	
	Standardized residuals	0.9	−1.3	
Terrace washing	Public supply network			$p < 0.001$
Total				
Group I: 54	Obs. Freq.	24 (44.4%)	35 (79.5%)	
Group II: 44	Standardized residuals	−1.5	1.7	
	Water hole or well			
	Obs. Freq.	30 (55.6%)	9 (20.5%)	
	Standardized residuals	1.8	−2.0	

[a] Chi-square test.

With regard to the education level of family members, it is the urban sampled household which holds higher academic levels than the group of the rural households. In each household, the most frequent number of inhabitants (mode) is 2, with "High school and higher education" and with "Basic education", in urban and rural respectively.

The results indicate that were found statistically significant differences concerning the number of inhabitants in each education level by environment: "No education" (p-value $= 0.029$), "Basic education" (p-value < 0.001), and "High school and higher education" (p-value $<$ 0.001). The average number of inhabitants with "No education" ranges from 0 to 2 for Group I (Rural), and 0 to 1 for Group II (Urban). Regarding the number of inhabitants with "No education" in both groups, it should be noted that the majority of the households have an education level (mode $= 0$) and also that both groups presents an average of about 0 inhabitants (mean $= 0.1$ and mean $= 0.03$). The standard deviation (0.16) of the urban area is less than half of the urban area (0.39), because the number of inhabitants with "No education" in this group is less variable.

Concerning the number of inhabitants with "Basic education", it is observed that rural environment presents an average of about two

Table 10
Comparison of rural and urban environment distributions relating to "Manual washing", "Manual washing in wash tub", "Efficiency class washing", "Timetable of washing machine uses", and "Water for manual washing".

		Group I (Rural)	Group II (Urban)	*p*-Value*
Manual washing Total Group I: 135 Group II: 110	Yes			$p <$ 0.001
	Obs. Freq.	59 (43.7%)	22 (20.2%)	
	Standardized residuals	2.1	−2.4	
	No			
	Obs. Freq.	76 (56.3%)	87 (79.8%)	
	Standardized residuals	−1.5	1.7	
Washing tank Total Group I: 135 Group II: 110	Yes			$p^a =$ 0.053
	Obs. Freq.	36 (26.7%)	18 (16.4%)	
	Standardized residuals	1.1	−1.3	
	No			
	Obs. Freq.	99 (73.3%)	92 (83.6%)	
	Standardized residuals	−0.6	0.7	
Efficiency class washing machine Total Group I: 135 Group II: 110	A+++			$p <$ 0.001
	Obs. Freq.	6 (5.0%)	16 (16.0%)	
	Standardized residuals	−1.7	1.9	
	A++			
	Obs. Freq.	12 (10.1%)	40 (40.0%)	
	Standardized residuals	−3.1	3.3	
	A+			
	Obs. Freq.	64 (53.8%)	31 (31.0%)	
	Standardized residuals	1.7	−1.9	
	A			
	Obs. Freq.	31 (26.1%)	10 (10.0%)	
	Standardized residuals	1.8	−2.0	
	B			
	Obs. Freq.	6 (5.0%)	3 (3.0%)	
	Standardized residuals	0.5	−0.5	
Timetable of washing machine uses Total Group I: 122 Group II: 96	8:00 am–11:59 am			$p =$ 0.002
	Obs. Freq.	7 (5.7%)	8 (7.7%)	
	Standardized residuals	−0.4	0.4	
	12:00 am–07:59 pm			
	Obs. Freq.	6 (4.9%)	8 (6.4%)	
	Standardized residuals	−0.6	0.6	
	08:00 pm–7:59 am			
	Obs. Freq.	15 (12.3%)	32 (30.8%)	
	Standardized residuals	−2.1	2.2	
	Random			
	Obs. Freq.	94 (77.0%)	56 (53.8%)	
	Standardized residuals	1.4	−1.6	
Water for manual washing Total Group I: 159 Group II: 21	Cold water			$p <$ 0.001
	Obs. Freq.	49 (83.1%)	5 (23.8%)	
	Standardized residuals	1.5	−2.4	
	Cold and warm water			
	Obs. Freq.	10 (16.9%)	16 (76.2%)	
	Standardized residuals	−2.1	3.5	

* Chi-square test.
[a] Significant at the 0.10 level.

inhabitants (1.8), a higher value than the one obtained for the urban environment, which presents an average of about one inhabitant (0.7). The data variability in both environments it's almost the same: (std.

Table 11
Comparison of rural and urban environment distributions relating to "Dishwasher", "Manual dishwashing", "Number of manual dishwashings", and "Water for manual dishwashing".

		Group I (Rural)	Group II (Urban)	*p*-Value*
Dishwasher Total Group I: 135 Group II: 110	Yes			$p =$ 0.002
	Obs. Freq.	59 (43.7%)	70 (63.6%)	
	Standardized residuals	−1.4	1.6	
	No			
	Obs. Freq.	76 (56.3%)	40 (36.4%)	
	Standardized residuals	1.5	−1.7	
Manual dishwashing Total Group I: 135 Group II: 110	Yes			$p^a =$ 0.051
	Obs. Freq.	122 (90.4%)	90 (81.8%)	
	Standardized residuals	0.5	−0.5	
	No			
	Obs. Freq.	13 (9.6%)	20 (18.2%)	
	Standardized residuals	−1.2	1.3	
Number of manual dishwashings Total Group I: 121 Group II: 89	0			$p =$ 0.006
	Obs. Freq.	2 (1.7%)	0 (0.0%)	
	Standardized residuals	0.8	−0.9	
	1 to 3			
	Obs. Freq.	14 (11,6%)	12 (13.5%)	
	Standardized residuals	−0.3	0.3	
	4 to 6			
	Obs. Freq.	9 (7.4%)	16 (18.0%)	
	Standardized residuals	−1.4	1.7	
	7 to 10			
	Obs. Freq.	65 (53.7%)	28 (31.5%)	
	Standardized residuals	1.6	−1.8	
	More than 10			
	Obs. Freq.	31 (25.6%)	33 (37.1%)	
	Standardized residuals	−1.0	1.1	
Water for manual dishwashing Total Group I: 120 Group II: 89	Warm water			$p =$ 0.028
	Obs. Freq.	50 (41.7%)	24 (27.0%)	
	Standardized residuals	1.2	−1.3	
	Cold and warm water			
	Obs. Freq.	70 (58.3%)	65 (73.0%)	
	Standardized residuals	−0.9	1.0	

* Chi-square test.
[a] Significant at the 0.10 level.

dev. = 1.09 and std. dev. = 1.03). In both environments it was observed the existence of households with 6 inhabitants (maximum) with "Basic education".

The number of inhabitants with "High school and higher education" varies between 0 and 4 for Group I (Rural) and 0 to 5 for Group II (urban). Note that in the rural environment the most frequent number is 0 people with these school qualifications, while in Group II it is 2 people (mode = 0 and mode = 2). Also, the mean of the number of inhabitants with "High school and higher education" in the urban area (about 2 persons) is twice that of rural area.

The number of active professional inhabitants in each household is greater in urban areas than in rural ones. In average, about 2 inhabitants and only 1 inhabitant are professionally active per household in the cities and in the countryside, respectively.

In the case of rural environment, the dispersion is higher, with a standard deviation of 1.18 people, compared to urban environment, with a standard deviation of 0.81 ($p = 0.001$).

The number of inhabitants without professional activity varies between 0 and 4 in the rural areas, and 0 and 3 in the urban ones. It should be noted that in rural areas the most frequent situation is 2 inhabitants without professional activity, while in urban areas no household presents this situation (mode = 2 and mode = 0). In the case of rural areas, the dispersion is again higher (std. dev. = 1.18) than in urban areas, with a standard deviation of 0.81 ($p < 0.001$).

The number of meals per week ranges from 2 to 24 for the rural group, and 0 to 45 for the urban group. It should be noted that in the rural group most frequently has 21 meals per week, while the urban group has only 14 meals (mode = 21 and mode = 14). The surveyed rural households present an average of 16.7 meals per week (std. dev. = 5.68), a higher value when compared with the urban ones, with a mean of 11.2 (std. dev. = 6.45), but the data variability is higher in urban areas. It can be concluded that the "Number of meals per week" is statistically significantly different in the two environments ($p < 0.001$).

3.2. Building information

Considering the 135 households that answered the survey in a rural region, 69.6% are "Single family dwelling (SFD), isolated" and only 14.5% of the 110 households in an urban region have this type of family dwelling (Table 6). In the urban regions, 70.0% of the households are "Multidwelling units (MDU)", in contrast to the rural environment, where only 3.7% of families are MDU. SFD and MDU categories are more frequent in rural environments, while MDUs tend to be more frequent in the urban areas, as expected.

The analysis of the discrepancies between the observed frequency and the expected frequency indicates that MDU and SFU categories are the most influential in the non-homogeneity of proportions, the first category containing fewer households in rural environments than expected, and the second category including a higher number than expected ($\chi2$ (2) = 124.081, p-value < 0.001).

Both groups under study assumed "Until 1990" as modal category for the year of dwelling constructions (64.7% in rural areas and 53.2% in urban ones), and only seven and fourteen households in rural and urban areas were built after 2006, respectively (Table 6). However, households in urban environments have newer dwellings, with 48% of the dwellings built "Between 1990 and 2006", and 13.6% built "Between 2006 and 2013" ($\chi2$ (2) = 17.124, p-value < 0.001). In Portugal, according to ICESD, only 7.5% of the dwellings were built before 1946 and 10.8% after 2000. In a regional analysis, it can be seen that in this country the period with higher values of construction was 1981–1999 (37.6%), followed by the period 1961–1980 (34.9%).

The data shows that houses with areas "Between 100 m^2 and 200 m^2" appear as a modal category in both study groups (39.3% and 49%, in rural and urban respectively). However, categories "Between 200 m^2 and 300 m^2" and "More than 300 m^2" are the most responsible for non-equality frequency counts distributions across the two studied environments ($\chi2$ (3) = 7.071, p-value = 0.07). The houses with a larger area, although in smaller number in both environments, are mainly in the countryside. The average area of accommodation in Portugal is around 107 m^2/household, (ICESD, 2010), what follows within the values obtained in here.

The significance level for this study was set to 5%, and it is used to refer to a pre-chosen probability of error. However, based on literature that considers the importance of certain variables in the characterization of water and energy consumption in rural and urban households, it is considered an error of $\alpha = 10\%$, as happened when the test of chi-square of homogeneity was applied to the house area variable from two different environments.

Regarding building typology, once again it is observed a contrast between the two environments: 96.3% are houses in a rural environment and 70.9% are apartments in an urban environment. It is statistically significant to conclude that the distribution of building typology for rural and urban environments is not the same ($\chi2$ (1) = 122.210, p-value < 0.001).

The data analysis of the two categories "yes" and "no" about the existence of gardens in the housing in both environments indicates that they are equally responsible for the statistically significant differences in the distributions, but the proportion of houses with a garden is higher than the expected frequency and, on the contrary, the observed frequency of houses without garden is less than the expected frequency. Thus, this confirms that the majority of the surveyed rural population has a garden (57%) and the majority of the surveyed urban population does not have a garden (73.6%) ($\chi2$ (1) = 23.232, p-value < 0.001).

As expected, concerning building information about exterior areas - terrace and backyard, most of rural households have higher frequencies of these type of outdoor spaces: terrace 63.7% (rural) versus 51.8% (urban), and backyard 50.4% (rural) versus 11.8% (urban) (Table 7). In particular, in rural regions the biggest frequency of terrace area is "Between 10 and 20 m^2" (46%), and in urban regions is "Less than 10 m^2" (49.1%).

Were found statistically significant differences, at $\alpha = 0.10$ level, in frequency counts distribution of rural and urban environments, about to have "Terrace" ($\chi2$ (1) = 3.524, p-value = 0.060), and about "Terrace area" ($\chi2$ (2) = 4.940, p-value = 0.085). It may be also concluded that the distributions of housing having or not having "Backyard" ($\chi2$ (1) = 40.706, p-value < 0.001) don't have identical behavior in the two studied groups.

As expected, due to the nature of the dwelling, only 20.6% of respondents of the surveyed households in an urban environment usually wash the cars per month at home; however, 60.8% of respondents in rural regions wash their cars at home (47.4% do one car washing per month and 13.4% two or more car washings per month). The "Number of car washings per month" distributions are not identical in the two environments ($\chi2$ (2) = 32.006, p-value < 0.001).

3.3. Energy consumption

A key goal of the survey was to study the rural and urban households 'consumption patterns concerning water and energy (natural gas and electricity)'.

In the case of households' annual natural gas consumption, 95.5% of the cases in the rural area does not use this energy source, using other sources of energy such as firewood, coal, pellets, gas oil, LPG and others. In urban areas, this energy source is not used in 49% of the cases, possibly due to the fact that some homes are not yet served with natural gas. In urban areas, the highest percentage (28.1%) of households spend between 0.019 and 0.041 toe natural gas per year (Fig. 3).

In this study, all households used two types of annual electricity consumption tariff: simple and dual tariff. The main difference between them is the price: simple tariff has only one price for all the daily period and dual tariff has two prices for two different daily periods.

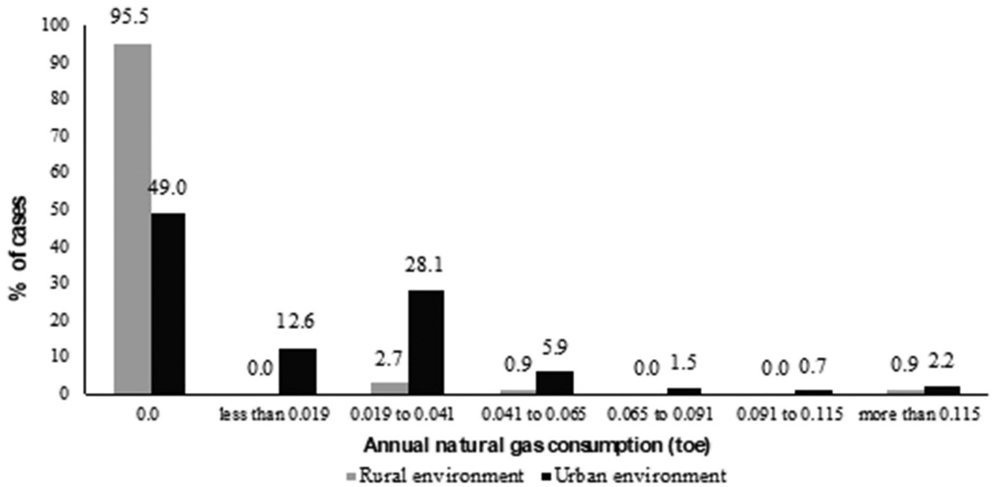

Fig. 3. Description of households' annual natural gas consumption.

The majority of families opted for a simple tariff: 89.6% in rural areas and 76.4% in urban areas (Table 8).

Fig. 4 displays the percentage of respondents using the annual electricity simple tariff by household environment. It is verified that the majority of them spend <0.016 toe of electricity (54.8% rural and 37.3% urban).

Fig. 5 illustrates the percentage of respondents using the annual electricity consumption with dual tariff by household environment. In rural areas, the highest percentage (3.7%) of households spend between 0.018 and 0.041 toe of electricity; in contrast, in urban areas (13.6%) spend <0.018 toe of electricity.

There is a tendency for the "Dual" tariff to be selected by urban households and the "Simple" tariff by rural households (by comparing the signal of the expected frequencies). The analysis of observed and expected frequency discrepancy indicates that the "Dual" tariff is the most influential category in the homogeneity of proportions by including fewer cases than predicted ($\chi2$ (1) = 7.808, p-value = 0.050) (Table 8).

3.4. Water consumption

Fig. 6 shows the annual water consumptions from a public supply network across two observed environments. The 10.4% of rural dwellings that did not present any type of water consumption from the public network only use water from a well or a hole, while in urban areas this situation happens in only 0.9% cases. More than half of the rural households (53.3%) consumes lower than 6 m^3 of water from a public supply network; in contrast, the majority of urban households (70%) consumes between 6 and 16 m^3.

In order to identify the domestic water source and water usage characteristics for domestic consumption in both environments several questions were made, particularly to find out if outdoor uses included water for garden irrigation and terrace washing (Table 9).

Nearly 89.6% of the surveyed households used the public supply network and all urban surveyed households (100%) used the same water source. Public supply network frequency counts are not identically distributed across the studied environments ($\chi2$ (1) = 12.099, p-value = 0.001). Only a small percentage of all respondents have water holes or wells (31.1% and 7.3%, in rural and urban areas, respectively), and, besides that, it was determined that the distribution of rural percentages differed significantly from the urban ones ($\chi2$ (1) = 21.205, p-value < 0.001).

Only 31.1% (rural) and 7.3% (urban) - corresponding to 8 households - use a hole or a well as their water sources for consumption. Besides that, no household in urban environment uses hole or well water for domestic use and only 15 households (11.3%) use hole and well water for domestic use ($\chi2$ (1) = 13.222, p-value < 0.001). Domestic consumption is entirely from the public supply network (100%) and also in the majority of rural households (88.7%).

Concerning the use of water from holes and wells, approximately 59.6% and 55.6% of the rural sampled households answered that they use this source of water for garden irrigation and terrace washing, but the majority of the urban households responded that they used water from the public supply network for garden irrigation (68%) and terrace washing (79.5%) (Table 9). Only 9 urban households used hole and well water for terrace washing and 8 for garden irrigation. This survey suggests that the use of the two types of source water (water hole or well and public supply network) in "Garden irrigation" ($\chi2$ (1) = 5.317, p-value = 0.021), and in "Terrace washing" ($\chi2$ (1) = 12.468, p-value < 0.001) is not the same in both regions.

Regarding water consumption related to personal hygiene (taking a shower or a bath), this study reflects that the number of showers the interviewed families have in a week is higher than the number of baths, in both environments.

The number of weekly showers in the households ranges from 1 to 50 (rural region) and 3 and 50 (urban region). It should be noted that in the rural group the most frequent number is 4 showers per week, while in the urban group it is 14 showers (mode = 4 and mode = 14) (Table 3). On average, 13.96 showers and 0.3 baths per week are taken by the rural families. The behavior of "Number of showers" per week is very variable, about 10 showers (std. dev. = 9.69) around the mean, but the "Number of baths" only varies 1 bath (std. dev. = 1.21). In comparison, the urban families present a higher average of 15.9 showers ($p = 0.045$) and 1.7 baths ($p = 0.01$), and standard deviations of 9 showers and about 6 baths per week, which represent an enormous data variability.

3.5. Washing

Regarding water consumption for clothes washing (machine and manually) it is verified that the following factors distributions are statistically significant different in rural and urban family environments: types of washing (washing machine usage, manual washing, manual washing in a washing tank), efficiency class washing machine, timetables and durations of washing machine uses, water for manual washing and duration of manual washing (Table 10).

Approximately 43.7% (rural) and 20.2% (urban) of the sampled households responded that they also wash clothes manually and, among these, a small portion of the families have a washing tank (rural 26.7% and urban 16.4%). Interestingly, for this type of task, 83.1% use cold water in rural environment and 76.2% use cold and warm water in urban environment (Table 10).

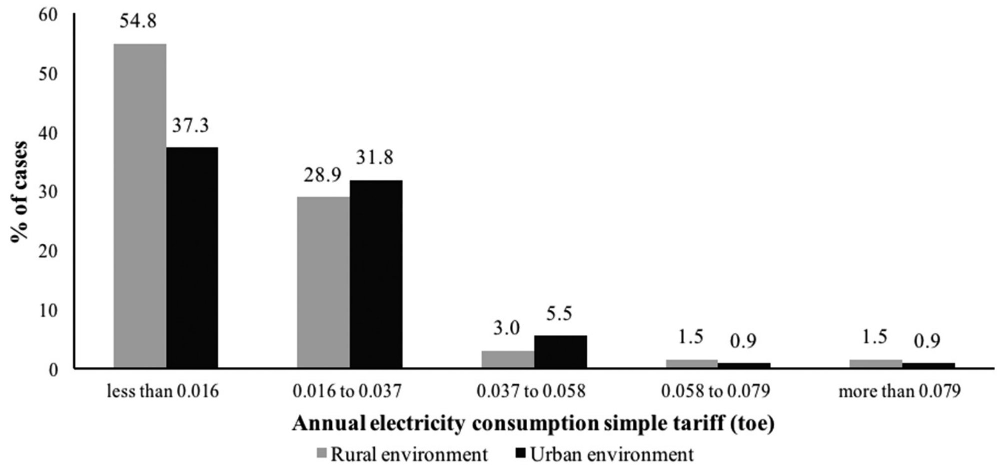

Fig. 4. Description of households' annual electricity consumption with simple tariff.

In both environments, there isn't a typical timetable for washing machine uses: 77% (rural) and about 54% (urban) responded that they used a random timetable. However, the timetable from 08:00 pm to 7:59 am for washing machine uses is the most responsible category for the non-homogeneity of the proportion of families in the two environments in the different timetables of washing machine uses: (more than twice the percentage of the families in urban areas (30.8%) in comparison to rural environment (12.3%)).

The efficiency class washing machine mostly used is class A^{++} in urban households (40%) and A^{+} in rural households (53.8%). Only a small number of houses use the A and B class washing machine: 5% (A) and 5.7% (B), and 3% (A) and 7.7% (B) in rural and urban environments, respectively. Class A^{++} is the most responsible category for the non-homogeneity of the proportion of families in the two environments concerning the different efficiency classes' washing machine.

The duration of the washing machine uses varies between 15 min and 240 min for rural households and 25 min and 180 min for urban households. It should be noted that in rural areas the most frequent duration of usage is 90 min while in the urban areas it is 60 min (mode = 90 and mode = 60). Particularly, an average of 86.8 min is observed in rural environment, and a standard deviation of 32.07 min, which represents a high variability of durations. In urban environment it was found an average of 78.1 min (SD 37.45 min), a lower average but an even greater variability of durations of washing machine uses, when comparing with rural areas (Table 3).

After analyzing the "Duration of manual washing", it is observed that the rural group presents an average of 22.9 min, almost twice the value mean 12.1 min of the urban group. The same happens for the dispersion of this category: a standard deviation of 11.43 min, almost twice the value standard deviation of 5.91 min (a greater variability of durations in rural area). It is important to emphasize that the minimum value observed was the same in both environments (5 min), but the maximum value observed was 60 min in rural area, which is the double of the maximum (30 min) observed in urban area (Table 3).

3.6. Dishwashing

Several variables distributions related to the dishwashing process involving water and energy consumption were analyzed and the results are presented only for those that were significantly different in both rural and urban environments (Tables 3 and 11).

In the two environments there is a greater number of families that don't use a dishwasher in rural area (56.3%) and, in contrast, a greater number of families use a dishwasher (63.6%) in urban area ($\chi2$ (1) = 9.660, p-value = 0.002). The majority of families also do manual dishwashing (90.4% rural and 81.8% urban), but the percentage of urban households that don't do manual dishwashing (18.2%) is higher than that in rural areas (only 9.6%) ($\chi2$ (1) = 3.804, p-value = 0.051).

Concerning the number of manual dishwashing per week, "7 to 10" is the modal category for rural environment (53.7%), and "More than

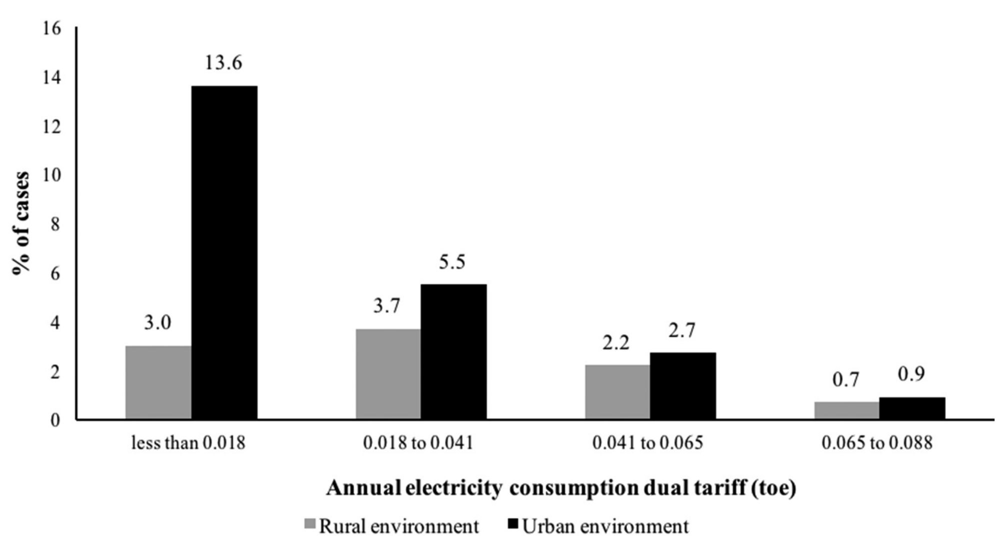

Fig. 5. Description of households' annual electricity consumption with dual tariff.

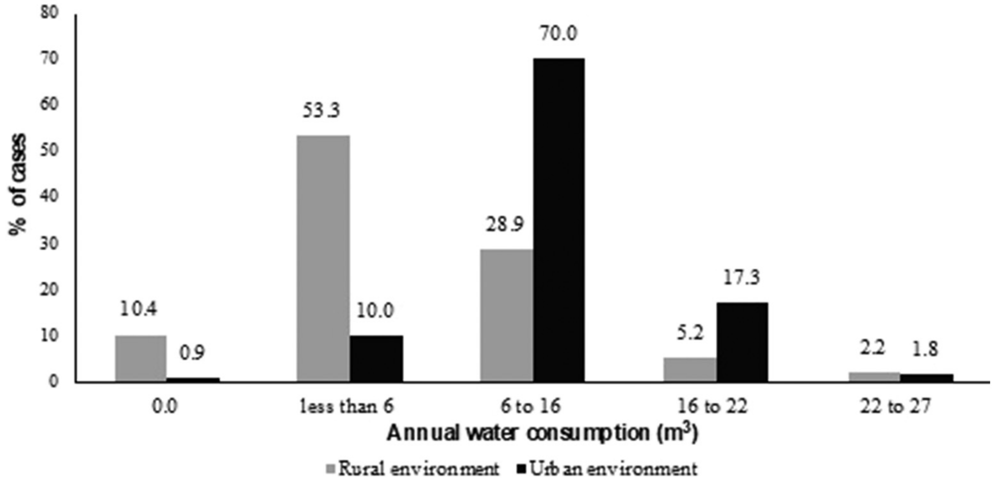

Fig. 6. Description of households' annual water consumption from a public supply network.

10" as modal category (37.1%) for urban environment. From the analysis of the residuals that arise in each of the categories, it is observed that the one that most influences the non-homogeneity of the proportion is "4 to 7" category (with a higher number of households in the urban group), surpassing what would be expected, and "7 to 10" manual dishwashing per week (with a higher number of households in the rural group), also exceeding the expected frequency ($\chi2$ (4) = 14.354, *p*-value = 0.006).

Considering the "Water for manual dishwashing" category, the majority of households use "Cold and warm water" (rural 58.3% and urban 73%). The analysis of the discrepancies between observed frequency and expected frequency indicates that category "Warm water" is the most responsible for the non-homogeneity of the distributions of proportions of "Water for manual dishwashing", containing more households of rural environment than expected ($\chi2$ (1) = 4.828, *p*-value = 0.028).

The temperature of dishwasher usage varies between 30 °C and 80 °C in rural areas and 10 °C and 100 °C in urban areas. It should be noted that the predominant temperature of dishwasher usage in rural households is 40 °C, while in urban households it is greater: 60 °C. The average temperature of dishwasher in urban environment (45.4 °C) is higher than in rural environment (53.5 °C) and the temperatures also present a higher variability in urban environment (SD values of 15.6 °C in urban environment and 12.6 °C in rural environment) ($p = 0.001$).

Both the mean and the standard deviation of dishwasher usage duration are higher in urban environment (mean = 82.5 min, std. dev. = 41.62 min) than in rural environment (mean = 65.5 min, std. dev. = 38.01 min). The duration of manual dishwashing varies in the two environments: from 30 to 180 min (rural) and from 29 to 185 min (urban). It was observed that in both regions the most frequent duration is 60 min of manual dishwashing. On average, the households spend 16.3 min in manual dishwashing, with a standard deviation of 5.31 min in rural environment in comparison with urban durations, whose average is 13.4 min, with slightly higher standard deviation (6.37 min) ($p < 0.001$).

4. Conclusions

In this research work, several differences between rural and urban environments were found. It is expected that the identified variables may influence the water and energy consumptions and so, an interconnected relation between water and energy can then be established.

The research started to consider >80 variables based on the bibliography, which decreased to 42 after the statistical treatment of the survey data.

In what concerns to occupant information, namely the socio-economic variables (housekeeper; professional activity; income; education level; employment) the results were significantly different. The number of positive answers was higher in urban than in rural households. In this category, as expected, it was found that in rural areas, the number of inhabitants in home per day was higher in rural than in urban areas. All these signs may have origin in the fact that rural population is usually older and so some of these inhabitants are already retired. The "age" variable did not show significant differences between the environments, however, the number of inhabitants with age higher than 67 years was bigger in the rural case (n = 99 to 20 answers in urban environment).

Relatively in the category of "Building information" for the variables type of housing, building typology, age of building, area, garden, terrace (presence and area), backyard and number of car washings per month, different results were obtained for the two environments. Some of them were expected, as the presence of garden, terrace and backyard is more in rural areas compared to urban areas.

In what concerns to "Energy consumption", it was noted that urban environments had more consumption of energy than the rural ones. However, in urban environments two types of resource energy are used: natural gas and electricity. In rural areas, electrical energy is predominantly used, given that most of the buildings are not served with natural gas installation. In rural areas dual tariff is not usual.

Annual water consumption is higher in urban areas than in rural environments. Although the number of holes and wells is higher in rural areas, almost all the domestic consumption is from the public water supply network, what reflects a high percentage if attendance with public facilities in this areas, as on the urban environments. Relatively to the water use, it was observed that in urban areas water is used mostly for hygiene and domestic consumption. Since the number of gardens and terraces is lower in urban areas, the consumption of water for these purposes was also expected to be lower.

Washing category reveals that in rural environments people do more manual washing in the washing tank. In urban environments there is greater concern with the energy class used which may be related to the education level of the urban population itself. This has implications on the duration of washing machine uses.

Finally, and in what concerns to "Dishwashing" category, urban households are generally served with a dishwasher, in contrast with rural households where manual dishwashing is bigger.

This research gives an important contribution to identify the factors responsible for the differences between rural and urban areas in what concerns to water and energy consumption.

Acknowledgement

This work was partially funded by POCI-0-0145-FEDER-016730 Project (PTDC/AAG-REC/4700/2014) with the designation ENERWAT:

Water to energy: characterization, modelling and measures for the reduction of urban and rural household consumption, financed by the Foundation for Science and Technology and co-financed by the European Regional Development Fund (FEDER) through the COMPETE 2020 - Programme Operational Competitiveness and Internationalization (POCI).

This work was partially supported by the FCT (Portuguese Foundation for Science and Technology) through the project PEst-OE/ECI/UI4082/2013 (C-MADE).

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.scitotenv.2018.06.062.

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