Journal of Environmental Management 348 (2023) 119247

Contents lists available at ScienceDirect

Journal of Environmental Management

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

Research article

Assessing environmental profiles: An analysis of water consumption and waste recycling habits

Marian García-Valiñas [a], Fernando Arbués [b], Roberto Balado-Naves [a,*]

[a] University of Oviedo, Department of Economics, Avda. del Cristo, s/n, 33006, Oviedo, Spain
[b] University of Zaragoza, Department of Applied Economics, C. de Violante de Hungría, 23, 50009, Zaragoza, Spain

ARTICLE INFO

Handling Editor: Raf Dewil

JEL classification:
C35
Q25
Q53
D19

Keywords:
Residential water consumption
Recycling habits
Latent Class analysis
Microdata
Pro-environmental attitudes

ABSTRACT

Individual pro-environmental attitudes and behaviors are determinant for long-term sustainability. We assessed profiles of an exclusive sample of 1351 households in the municipality of Gijón, Spain, in terms of their water consumption and recycling patterns using Latent Class Analysis (LCA). This methodology allows for households to be classified into groups without imposing any *ad hoc* criteria and provides information on the determinants of belonging to each group. The database includes the water consumption, self-reported environmental attitudes, and socioeconomic characteristics of the households. The results showed four significant household groups, where smaller families located in urban areas containing at least one homemaker and equipped with water efficient devices are more likely to present the best pro-environmental attitudes and behaviors related to water use and recycling habits. Furthermore, we found that providing better information in terms of water billing and the environmental impact of human behavior also fosters environmentally friendly habits.

1. Introduction

Achieving efficient levels of water consumption and waste generation is key for achieving the SDGs set out in the 2030 Agenda for Sustainable Development (UN, 2015), particularly those related to the 6.1, 6,5, 6b, 11.3, 11.6, 12.2, 12.5, 12.8 and 13.3 specific targets (UN, 2015). Regarding the EU area, and Spain in particular, the figures are worrying. Recycling rates for municipal waste, packaging waste, and electrical and electronic equipment waste have increased significantly in the EU area over the past decades. In 2004, the average EU-27 municipal waste recycling rate was 31.8%, while in 2020 this increased to 48.6%.[1] However, the level and evolution of these figures have been substantially heterogeneous across countries and over the years. In 2004, Spain registered a municipal waste recycling rate of 30.9%, which rose to 36.4% in 2020; however, this figure is still well below the EU-27 average (48.6%). Moreover, according to the latest report on Water Resources Across Europe (EEA, 2021), 20% of the European territory and 30% of the European population suffer from water stress, with the cost of economic damages due to drought measured between 2 and 9 billion euros annually.

In this context, identifying groups of individual green behaviors play a significant role in improving sustainability (Aljerf and Choukaife, 2016). “Pro-environmental behaviors” must be regarded as a multi-dimensional concept that includes a wide range of interconnected attitudes and actions (Barr et al., 2001a; Pirani and Secondi, 2011; Royne et al., 2011). While the literature analyzing the links between different eco-sustainable behaviors is increasing, works addressing this issue are still scarce. Therefore, we considered a novel microdata database consisting of a sample of households in the municipality of Gijón. The database itself is a significant contribution of this paper, since it merges information of a personal questionnaire with real data on water consumption. Regarding the survey, households were asked about several issues related to recycling and water-use habits, as well as environmental attitudes, their knowledge of environmental campaign, or the understanding of water billing.

Additionally, assessing pro-environmental behaviors in Gijón is relevant for three additional reasons: first, this municipality is located in Spain, a highly-exposed country to climate change and environmental risks, such as water stress or increasing temperatures (Pausas and Millán, 2019). Second, urban water supply managers in Gijón are very

* Corresponding author.
E-mail addresses: mariangv@uniovi.es (M. García-Valiñas), farbues@unizar.es (F. Arbués), baladoroberto@uniovi.es (R. Balado-Naves).

[1] For further information, check https://www.eea.europa.eu/ims/waste-recycling-in-europe.

https://doi.org/10.1016/j.jenvman.2023.119247
Received 11 May 2023; Received in revised form 12 August 2023; Accepted 2 October 2023
Available online 10 October 2023

concerned about water consumption reductions. For instance, per capita water consumption in Gijón is significantly higher than the 100 l/p/d optimal levels proposed by the World Health Organization (Howard et al., 2020) and the 80 l/p/d target purposed for Europe by Dworak et al. (2007). Third, waste sorting for recycling purposes has stagnated in Gijón after several years of sustained growth (EMULSA, 2022). To meet the objectives established in Law July 2022 on waste and contaminated soils for a circular economy (Official State Gazette, 2022), as well as in the European Directive 2018/851 amending Directive 2008/98/EC on waste (European Union, 2018), it is crucial to identify those users who are most likely to get involved in waste sorting.

Furthermore, our empirical approach attempts to address previous shortcomings in the literature. In contrast to previous works, which use factor analysis to classify households into different behavioral groups (i.e., Barr et al., 2005; Gilg and Barr, 2006), we carry out a latent class analysis which groups households according to their socio-economic and attitudinal variables. Although this methodology has been used in several works focused on single pro-environmental behaviors such as water use (Pérez-Urdiales and García-Valiñas, 2016; Thiam et al., 2021; Maier et al., 2022) or waste sorting (Yuan et al., 2015; Beaumais and Brunetti, 2018; Massarutto et al., 2019; Nainggolan et al., 2019), to the best of our knowledge, it has not been applied to empirical studies that address pro-environmental behavior from a multi-dimensional perspective.

The outline of the paper is as follows. Section 2 describes the methodology of analysis and the database, as well as the main variables used in the analysis. Section 3 presents the estimation results, while Section 4 discusses their relevance and Section 5 summarizes our major findings and their policy implications.

2. Material and methods

2.1. Latent class analysis

This paper aims to identify households by their behavior towards the environment. To do so, we classified them into different categories of unobserved heterogeneity following a latent class analysis procedure (Aitkin and Rubin, 1985; Wedel et al., 1993), studying the determinants and probabilities of belonging to each category.

A Latent Class Model (LCM) assumes that a sample of N individuals is randomly drawn from a population divided into J groups or categories (Cameron and Trivedi, 2005). Each observation i of the (NxT) $\boldsymbol{Y}$ vector of T environmental attitudes, extracted from subpopulation j, is characterized by the joint probability density function (*jpdf*) $f_j(\boldsymbol{Y}_i|\mu_j)$, where μ_j is the vector of subpopulation means of the $\boldsymbol{Y}_i$ vector of environmental attitudes. Additionally, the probability p_j of vector $\boldsymbol{Y}_i$ being extracted from the j subpopulation is assumed to take the following fractional logit specification

$$p_j(\boldsymbol{X}_i\boldsymbol{\beta}_j) = \frac{exp(\boldsymbol{X}_i\boldsymbol{\beta}_j)}{\sum_{j=1}^{J} exp(\boldsymbol{X}_i\boldsymbol{\beta}_j)} \tag{1}$$

where $\boldsymbol{X}_i$ is a (NxK) vector of exogenous observable characteristics and self-reported valuations that may be considered proxies for the underlying utility preferences (Fernandez-Blanco et al., 2009); $\boldsymbol{\beta}_j$ is a $(Kx1)$ vector of exogenous parameters, and $\sum_{j=1}^{J} p_{jt}(\boldsymbol{X}_i\boldsymbol{\beta}_j) = 1$. Now, defining d_{ij} as a dummy variable identifying $\boldsymbol{Y}_i$ as extracted from subpopulation j, the joint multinomial density can be written as

$$g(\boldsymbol{Y}_i|\mu_j, \boldsymbol{X}_i\boldsymbol{\beta}_j, d_{ij}) = \sum_{j=1}^{J} (p_j(\boldsymbol{X}_i\boldsymbol{\beta}_j)f_j(\boldsymbol{Y}_i|\mu_j))^{d_{ij}} \tag{2}$$

which consists of the sum of the J different *jpdf* of subpopulations or latent classes, weighted by the probability of being drawn from a given subpopulation p_j. From (2), the likelihood function to be maximized can be read as

$$\mathscr{L}(\boldsymbol{Y}_i|\mu_j, \boldsymbol{X}_i\boldsymbol{\beta}_j, d_{ij}) = \prod_{i=1}^{N} \sum_{j=1}^{J} (p_j(\boldsymbol{X}_i\boldsymbol{\beta}_j)f_j(\boldsymbol{Y}_i|\mu_j))^{d_{ij}} \tag{3}$$

Since d_{ij} are unobserved latent variables, (3) must be maximized following the expectation-maximization (EM) algorithm. Finally, the posterior probabilities of belonging to each latent class equal

$$Prob[\boldsymbol{Y}_i \in j] = \frac{p_j(\boldsymbol{X}_i\widehat{\boldsymbol{\beta}}_j)f_j(\boldsymbol{Y}_i|\mu_j)}{\sum_{j=1}^{J} p_j(\boldsymbol{X}_i\widehat{\boldsymbol{\beta}}_j)f_j(\boldsymbol{Y}_i|\mu_j)} \tag{4}$$

All estimations are carried out using the *gsem* command in Stata, and we consider several models with an increasing number of hypothesized latent classes. We follow a stepwise procedure where the final number of chosen latent classes depend on the comparison of the Akaike (AIC) and Bayesian Information Criteria (BIC) of each estimated model (Cameron and Trivedi, 2005).

2.2. Data

The database used in this study is one of the main contributions to the work. Most of the information was obtained from a household survey conducted between December 2020 and April 2021 in Gijón. While its implementation was initially scheduled as a face-to-face survey, the Covid-19 crisis prevented this. Also due to the pandemic, the survey was conducted via a mixed collection system, in which a letter with the questionnaire was sent to the households, which could choose to fill in and submit the survey by post or online. A 100% online survey was ruled out since it would have excluded a large percentage of people from participating, specifically those unfamiliar with smart technologies. Gijón is one of the Spanish cities with the oldest population (by 26% in the latest municipal Census).[2] Data from the survey were merged with information on actual water consumption provided by EMA. Initially, around 6800 households were contacted, with a response rate of 30%. After dropping some observations from the database and choosing/building the variables (some of them registered a high number of missing values), 1351 households were included in the final sample.

Garbage collection is entirely provided by the public company EMULSA[3] (Empresa Municipal de Servicios de Medio Ambiente Urbano de Gijón, S.A.). The entire provision of cleaning services (garbage collection, maintenance of containers, street cleaning, etc.) is partially funded by a bimonthly fixed fee charged to the citizens of Gijón. Citizens can dispose their garbage in any of the 9656 containers available across the municipality. The bulk of the waste container infrastructure is composed of high-capacity containers that are stationary and located at street level or underground. Recyclable waste can be dropped freely at any time with the exception of organic waste; containers for the latter require a citizen card to be opened. The remaining fraction can only be disposed of between 20:00–23:00, Sunday to Friday.

The waste container infrastructure is organized as follows: 34.63% (3295) is devoted to non-recyclable waste; 13.37% (1272) to organic waste; 50.14% (4770) to cardboard, paper, glass, non-ferrous metals, and plastic and packaging; and 0.609% (58) to pruning waste, with containers located in suburban or rural areas. Additionally, EMULSA fits out different containers and waste and recycling drop-off sites ("puntos limpios", according to the Spanish name) for special waste disposal. Clothes can be disposed of in 67 special containers on specific streets (0.704% of the waste container infrastructure), batteries in 143 containers on and below street level (1.481%), and residential vegetable oils

[2] For further information, see https://observa.gijon.es/pages/inicio.

[3] For further information, check https://drupal.gijon.es/sites/default/files/2022-08/MEMORIA%2BEMULSA%2B2021%2BVERIFICADA.pdf.

can be recycled in 51 special bins located at supermarkets (0.536%). Therefore, more than 60% of the container infrastructure units are devoted to recycling.

Waste and recycling drop-off centers also allow citizens to dispose of their day-to-day waste, as well as other items, including hazardous waste. Gijón has four waste and recycling drop-off centers, half of them located at the outskirts of the urban area (see Fig. 1). They tend to be open most of the day from Monday to Saturday and can be used free of charge by individuals with a citizen card. Users are restricted to dropping off a limited amount of each type of waste per day, which must be registered before accessing the center. The following waste products can be dropped off at these centers: automotive waste (synthetic oil, tires, lead batteries, …), selective waste (paper/cardboard, packaging, glass, books, …), electrical waste (household appliances, fridges, televisions, batteries, cell phones, …), construction and large waste (debris, furniture, mattresses, natural wood, metals, plastic, …), and hazardous and toxic waste (paint, solvents, medicines, discs, packaging with hazardous materials, …).

In addition to waste and recycling drop-off centers, households can dispose of their furniture and medicines by other means. Regarding furniture, citizens must first evaluate whether it is in good condition or not. If so, social inclusion companies, such as EMAUS-RIQUIRRAQUE or CENTRO RETO provide free-of-charge pickup services. If it is in poor condition, EMULSA offers free-of-charge pickup services, as well as the aforementioned waste and recycling drop-off centers. As far as medicines are concerned, all pharmacies have a special recycling bin, called a SIGRE point, where medicinal waste can be recycled. Furthermore, for electrical and electronic devices, as well as toys and playthings in good condition, EMULSA offers an exchange service among citizens through the free app REUSAPP. These devices and toys can be deposited and withdrawn from the Roces waste and recycling drop-off center, with a maximum retrieval limit of five products.

Rural areas present the highest number of available recycling points per capita (60 inhabitants per batch of recycling containers), though their spatial distribution is sparser compared to urban areas. In contrast, the center of the urban area (yellow area in Fig. 1) presents the most congested part of the municipality, with 194 citizens per container batch, with most containers mainly located below ground. Nevertheless, the location of the waste and recycling drop-off centers within the urban area (blue points in Fig. 1) may alleviate the pressures on waste disposal of such highly densely populated areas, as well as improve the pro-environmental patterns of the urban population in terms of correct disposal of hazardous waste.

The water supply is entirely managed by the public company EMA (Empresa Municipal de Aguas de Gijón). The provision of water services is partially funded by a bimonthly fixed rate combined with a three-block increasing variable rate. According to the last available EMA Annual Report (2020), the public company had over 5 water cycle management and supervision facilities, 27 water depots, 4 water sources, and more than 2000 km of pipework for water distribution and wastewater which reaches most rural areas. In terms of management and supervision facilities, the EMA has a drinking water and wastewater treatment plant, as well as two wastewater pre-treatment plants. Located in the rural part of the city, these plants also have laboratories to control the quality of the water cycle. As per the report, the quality of drinkable water met the general requirements and presented chlorine compliance levels superior to 96%, while the purification system managed to eliminate an average of 74% of pollutants.

2.3. Variables capturing environmental attitudes

Environmental behaviors must be regarded as a multi-dimensional concept that includes a wide range of interconnected attitudes and actions (Barr et al., 2001a; Pirani and Secondi, 2011; Royne et al., 2011). While the literature analyzing the links between different eco-sustainable behaviors is increasing, works addressing this issue are still scarce. Barr et al. (2005) expanded on the analysis of waste management behaviors carried out by Barr et al. (2001a, 2001b). They grouped households into four behavioral clusters with different socio-economic characteristics based on diverse pro-environmental actions, some of which were associated with water saving. Along this line, Gilg and Barr (2006) carried out the same analysis as Barr et al. (2005), focusing on water saving attitudes. Pirani and Secondi (2011), as well as Yang and Arhonditsis (2022), used a hierarchical modelling framework to analyze the demographic and socio-economic covariates of pro-environmental behaviors of households. They considered a number of dimensions related to activism, lifestyle, and multiple household practices concerning air quality, sorting waste for recycling, energy conservation, and water saving. Furthermore, Smiley et al. (2022) analyzed the propensity of people to adopt pro-environmental actions to combat climate change, based on the influence of a set of socio-demographical and attitudinal variables. According to them, environmentally friendly actions can be proxied by four registered habits: renewable energy use, water saving, restricted overall consumption, and use of greener and alternative transportation methods compared to personal cars.

Although the complementarity between energy and water conservation behaviors has been widely analyzed in the literature (Dieu-Hang et al., 2017; Jin et al., 2017; Antunes and Ghisi, 2020; Casazza et al., 2021; Costa et al., 2011; Liobikienė and Minelgaitė, 2021; Liu et al., 2021; Kheirinejad et al., 2022; Sanguinetti et al., 2022), most of the empirical literature on environmental attitudes and behaviors has focused on specific activities like recycling (Hornik et al., 1995; Oskamp et al., 1998; Czajkowski et al., 2017), waste sorting (Arbués and Villanúa, 2016, 2022; Aprile and Fiorillo, 2019; Massarutto et al., 2019), water saving (Pérez-Urdiales and García-Valiñas, 2016; Alvarado et al., 2021; Zhu et al., 2021) or energy conservation (Gillingham and Tsvetanov, 2018; Fiorillo and Sapio, 2019; Kumar et al., 2022).

In light of previous literature, we adopt a multi-dimensional approach to analyze several pro-environmental behaviors related to water usage, as well as waste disposal and recycling. This is captured by a vector of four proxy variables. Two are related to declared recycling habits indexes, which are calculated using the information obtained from two survey questions (see Table A1 in the Appendix). The first one (*iw_rhabit*) is a weighted habit index of global waste recycling. We distinguished between non-hazardous (glass, plastics and packaging, paper and cardboard, and organic waste) and hazardous waste (used oil, batteries, and medicines/drugs).[7] We calculated two subindices corresponding to each kind of waste, assigning the value 1 if the household recycles each product and 0 otherwise, summing up all values and dividing the total sum by the total number of items in each category. Then we calculated a weighted average of those subindices using 0.4 for non-hazardous waste and 0.6 for hazardous waste. This approach would give a higher weight if those products which are more harmful to the environment are recycled. If nothing is recycled, this variable takes the value 0. The second index is related to the correct disposal of small electric appliances, electronic devices, and furniture. Similarly, the value 1 was assigned if a household recycled each product and 0 otherwise, aggregating all the habits and dividing the sum by the total number of items.

On the other hand, two variables related to the water sector were defined. The first was based on another survey question (see Table A2 in the Appendix) and was built in a similar fashion to the previous indices. Households were asked if they had adopted several habits related to water use. A value of 1 was assigned when the household adopted the habit, or 0 otherwise. The values were summed up and the total amount divided by the number of habits. Finally, the last dependent variable was household water consumption corresponding to the second billing

[7] This classification was proposed by the European Commission. For further details, see https://ec.europa.eu/eurostat/.

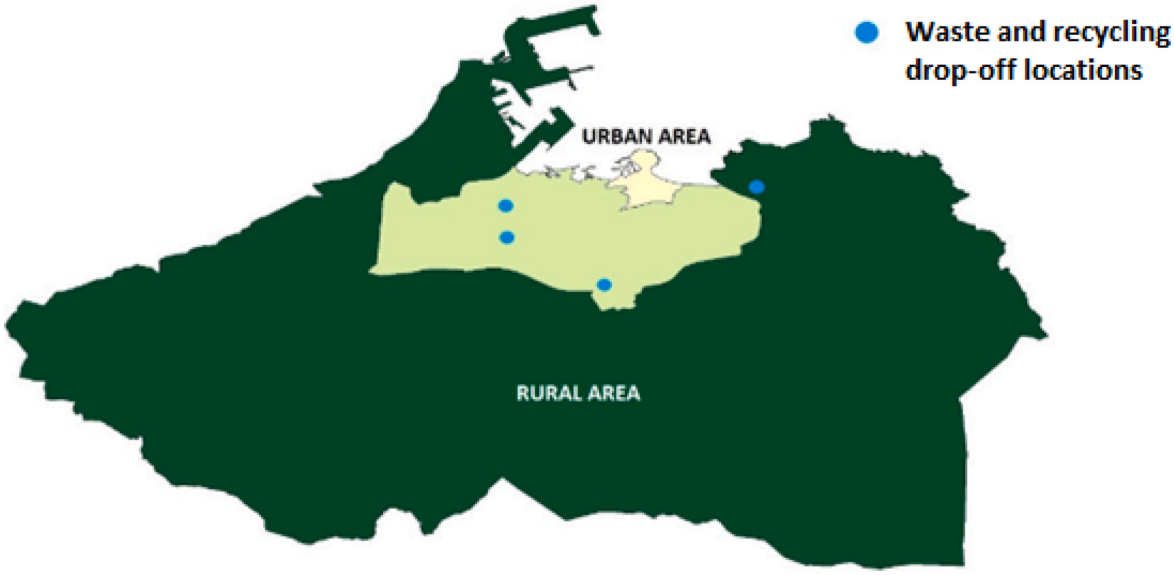

Fig. 1. Main areas of Gijón and distribution of waste and recycling drop-off centers.[123]
Source: Elaborated by the authors with data from the City Council of Gijón website[4 5] .[6] Notes: The urban area has been subdivided into the city center and the rest of the urban area.

period of 2021. Contrary to previous indices, this variable is representative of an observable behavior.

2.4. Determinants of environmental attitudes

With regard to determinants of being a member of a certain group of environmentally-friendly attitudes, we considered several groups of factors based on the previous literature. In the attempt to capture the socio-economic profiles of individuals, the most common variables are income, education, and age (Yang and Arhonditsis, 2022; Gilg et al., 2005; Gilg and Barr, 2006; Pirani and Secondi, 2011), followed by the relationship with the economic activity (Pirani and Secondi, 2011), the household size (Gilg and Barr, 2006; Yang and Arhonditsis, 2022), or the area of residence (Pirani and Secondi, 2011; Yang and Arhonditsis, 2022). Variables definition is displayed in Table 1.

First, certain socioeconomic household features were included: household income higher than 2700 euros per month (*highinc*), family size (*hsize*), household age composition, with the percentage of family members in different age brackets (*p_age18*, *p_age29*, *p_age65*), if at least one household member is a homemaker and/or is unemployed (*homemaker; unemployed*) and if the first and/or second household members have a postsecondary degree (*college*).

Information on public services was another important factor and was captured through the variable *wbill*. As in other Spanish cities, the water bill reports information on both water and waste collection services, offers data on fees/prices, water consumption, and other notifications related to these services. Therefore, the water bill stands out as a crucial information channel between the public sector and citizens, as it contains key information that can impact behaviors and attitudes. As shown in Table 2, for a significant percentage of households, for several reasons, their water bill does not provide sufficient information on key

Table 1
Variables definition.

Variable	Definition
iw_rhabit	Global waste recycling habit weighted (*) index
i_r3habit	Household goods recycling habit index
i_whabit	Water habit index
m3ph	Household water consumption in m3 (2 month-billing period)
highinc	Net family income higher than 2700 euros/month
hsize	Number of people living in the residence
p_age18	Proportion of family members younger than 18
p_age29	Proportion of family members between 18 and 29
p_age65	Proportion of family members older than 65
homemaker	At least one household member is a homemaker
unemployed	At least one household member is unemployed
college	First and/or second household members have postsecondary degree
wbill	Water bill is sufficiently detailed
users	Number of apartments measured with the same meter
dev_effic	Water-saving devices installed
app_effic	Some electrical appliances have water-saving and/or efficient energy rating
camp_save	The respondent is aware of any campaigns to promote saving water
env_prog	The respondent is aware of the environmental general educational program
smhouse	House surface area is not larger than 60 m2
daysaway30	Household spends more than 30 days away from residence
rural	Household lives in a rural area

Notes: (*) weights: 0.4 non-hazardous waste; 0.6 hazardous waste.
Source: Own elaboration.

Table 2
Main statistics.

Variable	Obs	Mean	Std. Dev.	Min	Max
iw_rhabit	1741	.821367	.2288968	0	1
i_r3habit	1437	.7974948	.2934125	0	1
i_whabit	1773	.6504404	.1349007	0	1
m3ph	1773	16.1972	10.7535	0	166
highinc	1556	.2512853	.4338917	0	1
hsize	1773	2.4078	1.05122	1	6
p_age18	1773	.1025287	.1813008	0	.67
p_age29	1773	.0855236	.1737068	0	1
p_age65	1773	.3020023	.4174705	0	1
homemaker	1773	.1618725	.3684378	0	1
unemployed	1773	.1460801	.3532861	0	1
college	1773	.4782854	.4996692	0	1
wbill	1729	.4441874	.4970189	0	1
users	1773	9.1664	13.7605	1	93
dev_effic	1725	.5130435	.4999748	0	1
app_effic	1710	.1842105	.3877692	0	1
camp_save	1763	.4163358	.4930905	0	1
env_prog	1773	.1601805	.3668768	0	1
smhouse	1680	.1380952	.3451026	0	1
daysaway30	1773	.1979695	.3985815	0	1
rural	1773	.1607445	.3673987	0	1

Source: Own elaboration.

water and waste collection concerns. The survey asked households if the water bill is sufficiently detailed. The available responses were 1) Yes; 2) No; 3) I do not receive a bill at this residence; and 4) I receive a bill but I do not remember. We transformed the original variable into a dummy variable to capture the effect of households receiving sufficient information on water and waste collection services through the bill.[8] With this variable, it is also assumed that inattentive households or those that do not receive the bill are not well-informed about these issues.

Another group of variables is related to house equipment. The number of flats measured with the same water meter was included as an explanatory variable (*users*). This variable can show if there is a collective meter and, subsequently, the different water tariffs and the difficulties in assigning responsibilities for water consumption. Additionally, two variables related to water efficient technologies were included (*dev_effic*, *app_effic*), distinguishing between devices that do not use energy (devices to control water pressure, efficient toilets) and appliances that do (washing machines and dishwashers).

Moreover, three additional variables captured the respondents' environmental attitudes: if the respondent is aware of campaigns to promote water savings (*camp*_save), and familiar with the environmental program organized by the water company (*env_prog*). It was expected that people who are more aware of environmental problems would be more likely to display more environmentally friendly behaviors.

Lastly, three extra variables related to space or time availability were included in the estimates: if the household lives in a small house (*smhouse*) no larger than 60 m^2, if the household spends more than 30 days away from the residence (*daysaway30*), and if the household lives in a rural area (*rural*). The first and second variables represent space constraints (people living in small houses in urban areas are expected to consume less water but have less room to recycle at home). Additionally, it is more likely that people who travel do not recycle frequently but it also is probable that they consume less water.

Table 2 presents the main descriptive statistics. On average, households reported having better waste recycling habits than water use habits. The representative household from the sample consumes 16 m^3 per billing period (around 267 L per household per day) and has 2.4 members.[9] As mentioned before, it is quite an aged population, as seen in the percentage of family members older than 65. A relatively high percentage of households (around 15% and 16% respectively) has an unemployed member or a homemaker. In 48% of households, at least one of the main members has postsecondary studies.

Concerning information issues, 44% of households reported receiving useful information about water and waste collection services via the bill. Regarding house equipment, the average number of flats measured by a single meter is around 9 (a significant presence of collective meters was detected). Moreover, 51% of households have water efficient devices installed, but only 18% have energy and/or water efficient appliances. Around 37% of respondents are very concerned about environmental problems, while 42% are aware of campaigns to encourage saving water. However, not many people (16%) are aware of the environmental programs organized by the water company. Finally, around 20% of households spend more than 30 days away from home, 14% of households live in small flats, and 16% are located in rural neighborhoods.

3. Results

As explained in Subsection 2.1, we first choose the optimal number of latent classes which leads to the model that best fits to data. Table 3 displays the results of AIC and BIC for each model. Both criteria clearly decrease from 2 to 4 classes, and increase again for the 5-class case. Based on these results, we focus our study on the four-class model.

Tables 4–5 present the results of the four-class model. Looking at Tables 4 and it is possible to observe the main features of these groups in terms of their reported environmental habits and behaviors. Furthermore, Table 5 captures the main determinants of class membership. Finally, Table 4 shows some figures related to class membership based on posterior probabilities predicted for each household[10].

According to the LCM estimates, the households were classified into four groups. Strong differences regarding efficient environmental indices were detected, except in the case of declared water habits, where values were similar across the 4 classes considered. A description of each group is provided below, connecting the class characteristics with the key drivers for belonging to each class.

Individuals in Class 1 exhibited the worst self-reported habits in terms of recycling and water use. However, their observed water consumption is the lowest level recorded. As mentioned in both Tables 4 and 5, Class 1 is the benchmark group of the LCM estimates. Posterior probabilities showed that 17.53% of households in the sample would be classified into this group.

Class 2 comprises the households with the best declared environmental habits and the second lowest water consumption level. Based on posterior probabilities, this is the largest group, with 56.33% of the households. It is noteworthy that these households present strong recycling behaviors related to all kinds of waste. Regarding the determinants of belonging to this group, the presence of a homemaker in the household, a higher proportion of members between 18 and 29 years, as well as older than 65, or having at least one member with a postsecondary degree increased the probability of belonging to this class with respect to the reference group (Class 1). Additionally, smaller-sized households, or those endowed with water-saving devices are more likely to be members of this group. A similar effect was detected when the respondent was aware of the environmental educational program or considered the water bill to be sufficiently detailed.

Households in Class 3 also exhibited very good recycling habits but presented the second worst index of water habits as well as much more higher consumption levels. In terms of predicted probabilities, this is the smallest group (3.61% of households). As seen in Table 5, they have different characteristics compared to Class 2. A unique feature is the significance of living in rural areas, which increases the probability of belonging to Class 3 with respect to the benchmark group. Similar to Class 2, households with large shares of elder members, or with high

Table 3
Information criteria in LCM estimates: AIC and BIC.

Model	N	AIC	BIC
2-Class	1358	6761.436	6917.849
3-Class	1358	6385.755	6656.871
4-Class	1358	4675.853	5061.672
5-Class	1358	5298.965	5799.486

Source: Own elaboration.

[4] For further information, check https://drupal.gijon.es/sites/default/files/2022-08/MEMORIA%2BEMULSA%2B2021%2BVERIFICADA.pdf.

[5] Detailed information is available at https://gijon.opendatasoft.com/explore/dataset/contenedores-emulsa/map/?flg=es&disjunctive.t_entidad&location=12,43.50547,-5.69144.

[6] For further clarification, check https://observa.gijon.es/explore/dataset/padron-de-habitantes-actual-poblacion-urbana-por-barrios-sexo-y-grupos-de-edad/table/?flg=es.

[8] Dummy takes a value of 1 when respondents firmly state that the water bill is sufficiently detailed and, as such, a source of valuable information.

[9] This figure is in line with the results published by the Spanish National Statistics Institute (INE, 2021), reporting an average household size of 2.2 in the region (Principado de Asturias).

[10] Probabilities were predicted after estimating LCM and households were allocated into the group with the highest probability.

Table 4
Estimated class characteristics and class membership based on posterior probabilities.

	iw_rhabit	*i_r3habit*	*i_whabit*	*m3ph*	Freq.	Percent
Class 1	0.435***	0.2393***	0.608***	14.425***	238	17.53
Class 2	0.973***	1***	0.666***	14.618***	765	56.33
Class 3	0.950***	0.992***	0.638***	42.196***	49	3.61
Class 4	0.732***	0.666***	0.655***	15.323***	306	22.53
log-likelihood −2263.9265					1358	100.00

Notes: Class 1 is the benchmark of the Fractional Logit Model. *$p < 0.10$, **$p < 0.05$, ***$p < 0.01$.
Source: Own elaboration.

Table 5
Determinants of class membership.

	Class 2	Class 3	Class 4
highinc	0.175	0.61	0.670***
hsize	−0.239**	0.582**	−0.165
p_age18	0.219	0.394	0.964
p_age29	0.950*	2.225	0.507
p_age65	0.467**	1.929**	0.311
homemaker	0.670**	0.58	0.574*
unemployed	−0.111	0.856*	0.131
college	0.416**	1.185**	0.135
wbill	0.574***	−0.144	0.162
users	−0.006	−0.125**	−0.012*
dev_effic	0.579***	−0.055	0.460**
app_effic	−0.081	0.395	−0.042
camp_save	0.159	0.524	0.27
env_prog	0.964***	−2.576	0.258
smhouse	−0.188	−0.509	−0.236
daysaway30	−0.064	−1.092	0.079
rural	−0.248	1.918***	−0.448
constant	0.599**	−5.345***	−0.164

Notes: Fractional Multinomial Logit Model results after LCM with four classes. Class 1 is the benchmark. *$p < 0.10$, **$p < 0.05$, ***$p < 0.01$.
Source: Own elaboration.

levels of education increase the likelihood of being included into Class 3 compared to Class 1. On the contrary, large families are more likely to be found in this class. Other significant determinants are the work status of the household members, or the number of users measured by the same water meter. In this sense, having at least one unemployed member increases the probability of being part of Class 3 with respect to Class 1, while sharing the water meter reduces the probability of being part.

Lastly, households in Class 4 did not report having the best recycling habits, and their water indices were similar to the households in Class 2. Households with high income levels, a homemaker or stay-at-home parent, or with efficient devices installed are more likely to belong to this group with respect to the benchmark group. On the other hand, being part of a building with many users sharing the water meter reduces the likelihood of belonging to this group with respect to the reference group.

4. Discussion

To frame the discussion of the results, the average marginal effects corresponding to the four groups are displayed in Table 6. These figures help us understand the relative average weight of each variable when it comes to explaining pertaining to each class.

One of the most relevant findings is the lack of differences in water saving behaviors between households who have or have not invested in some efficient appliances (dishwasher, washing machine, etc.). On the contrary, investing in water-saving devices (*dev_effic*), such as efficient taps or toilet flushes, increases the likeliness to be a member of the environmentally-friendly class (Class 2), at the same time decreases the likeliness to be part of the environmentally-harmful class (Class 1). The

Table 6
Average marginal effects by class.

Determinants	Class 1	Class 2	Class 3	Class 4
highinc	−0.046* (−1.66)	−0.050 (−1.41)	0.009 (0.67)	0.087*** (3.04)
hsize	0.025* (1.75)	−0.043** (−2.16)	0.020*** (2.86)	−0.002 (−0.16)
p_age18	−0.061 (−0.84)	−0.072 (−0.74)	0.001 (0.03)	0.132 (1.62)
p_age29	−0.120 (−1.63)	0.121 (1.27)	0.043 (1.17)	−0.044 (−0.54)
p_age65	−0.066** (−2.16)	0.039 (0.99)	0.044** (2.32)	−0.017 (−0.5)
homemaker	−0.088** (−2.52)	0.074* (1.75)	0.001 (0.11)	0.011 (0.32)
unemployed	0.0002 (0.01)	−0.054 (−1.38)	0.024* (1.71)	0.029 (0.89)
college	−0.050** (−2.07)	0.060* (1.86)	0.025* (1.76)	−0.035 (−1.3)
wbill	−0.058** (−2.49)	0.114*** (3.78)	−0.014 (−1.26)	−0.041 (−1.58)
users	0.001** (2.07)	0.002 (1.36)	−0.003* (−1.85)	−0.0004 (−0.4)
dev_effic	−0.071*** (−3.35)	0.077*** (2.74)	−0.013 (−1.1)	0.007 (0.31)
app_effic	0.006 (0.25)	−0.019 (−0.49)	0.012 (0.67)	0.0001 (0)
camp_save	−0.028 (−1.29)	−0.004 (−0.16)	0.010 (0.84)	0.022 (0.93)
env_prog	−0.085** (−2.07)	0.229*** (2.99)	−0.088 (−0.75)	−0.056 (−1.3)
smhouse	0.029 (1)	−0.006 (−0.15)	−0.009 (−0.36)	−0.013 (−0.37)
daysaway30	0.008 (0.33)	−0.007 (−0.2)	−0.029 (−1.38)	0.028 (1)
rural	0.030 (0.96)	−0.032 (−0.71)	0.060*** (3.71)	−0.058 (−1.57)

Notes: t statistics in parentheses. *$p < 0.10$, **$p < 0.05$, ***$p < 0.01$.

non-significant effect of efficient appliances can be explained by the composition of these households. In this sense, Class-2 households present large shares of elder members, who often face strong barriers to operate these devices at their full water-saving potential (García et al., 2022). Furthermore, the so-called 'rebound effect' could be playing a role, where efficiency gains derived from technological change are absorbed by behavioral changes (Fielding et al., 2012).

Regarding the attitudinal variables, the obtained results are heterogeneous. First, the effect of the specific education program in water-saving habits (*camp*_save) was non-significant. This result may be because, at least in Spain, water-saving campaigns are focused on habits that people have already internalized (March et al., 2015). Second, the variable (*env_prog*) which captures the influence of the general pro-environment program shows that knowing of its existence increases the likelihood of belonging to the pro-environmental group (Class 2) and leaving the worst performing group (Class 1). Furthermore, its marginal effects show it as the variable with the greatest impact on shifting individuals from the environmentally-harming group to the environmentally-friendly one (being aware of this program increases the likelihood of being part of Class 2 in 22.9 percentage points, while decreases the likelihood of being in Class 1 in 8.5 points). Therefore, these results point to the general environmental awareness programs as a powerful tool for promoting eco-friendly attitudes in the households, much more effective than programs focused on specific environmental issues.

Focusing on the socio-economic variables included in the analysis, our estimation in Tables 5 and 6 shows that some eco-friendly behaviors tend to be related to the spatial location. It seems that good recycling habits alongside elevated levels of water consumption can be found in rural areas. It should be noted that although the most commonly used criterion to establish the urban/rural division is population density, in practice there are different contextual factors (e.g., type of dwelling, housing equipment installed, etc.) that may be relevant to explaining the differences in pro-environmental behaviors among households in these areas (Anderson and Krettenauer, 2021).

Regarding education level, we observed that this increases the probability of adopting eco-friendly attitudes (the probability of being in Classes 2 and 3 and not in Class 1 was positively linked to this variable). This result is similar to that observed in previous works, such as Barr et al. (2005), Gilg and Barr (2006) or Yang and Arhonditsis (2022). Nevertheless, the relationship between education level and the water saving dimension of pro-environmental behavior is, in part, unclear because households in Class 3 showed high water consumption levels. Since the marginal effect of increasing average education levels in Class 2 more than double that of Class 3, we can expect a positive net effect of education. Furthermore, this effect is reinforced by the negative marginal effect of education on the likelihood of belonging to Class 1. Similarly, information issues also play a significant role, as seen in the marginal effects estimated for *wbill*. Thus, for those households that reported the water bill is sufficiently detailed, the probability of belonging to the environmentally-friendly class increase.

Regarding age, the positive relation observed between the average age of households and pro-environmental behaviors is parallel to previous research (Steel, 1996; Barr et al., 2005; Gilg and Barr, 2006; Pirani and Secondi, 2011). Specifically, our estimation indicates that the presence of a high proportion of people older than 65 increases the likelihood of being part of the best-performing class and decreases that of worst-performing class (Class 1). However, the positive relationship between this variable and water saving attitudes is not entirely clear because the marginal effects for Class 2 is non-significant, but it is for Class 3 (0.044), which leads to better recycling habits at the expense of high water consumption.

Lastly, as the number of people living in a household decreases, the likelihood of having very good environmental habits (belonging in Class 2) increases. Note that this result is consistent with previous works such as those by Barr et al. (2005) and Gilg and Barr (2006). We also found those households where one member is a homemaker tend to adopt better environmental attitudes. The marginal effects show that the probability of being in Class 1 diminishes by 8.8 percentage points when there is a homemaker while the probability of being in Class 2 increases by 7.4 points. This result is consistent with the fact that these household members have enough time to perform household chores, including sorting waste and water-related tasks (cleaning, washing, etc.). It is noteworthy that this variable has not been analyzed in any previous empirical work with a multidimensional approach to environmental behavior.

5. Conclusions

Water consumption management and waste recycling are key behavioral dimensions that should not be overlooked. According to the United Nations, there is still a long path ahead towards achieving specific Sustainable Development Goals (UN, 2022). The challenges presented in the 2030 SDG framework will require significant support in terms of behavioral patterns. Understanding how households in a city similar to Gijón, highly involved in promoting eco-friendly behaviors among its citizens, may be a good benchmark for other cities seeking to build a more sustainable urban environment.

According to our results, small families with homemakers have a higher probability of belonging to the most environmentally-friendly group. Lower requirements and coordination efforts and more potential time devoted to these activities back up those findings. The results related to the age composition of household members did not return clear profiles for efficient water consumption. However, aged households are more likely to present better recycling habits. Additionally, being located in rural areas is also significant since it affects water consumption (housing features such as swimming pools or gardens), but also space availability and better recycling habits. Furthermore, providing better information on water tariffs, as well as environmental general programs were identified as powerful tools to generate good environmental attitudes and habits.

On the one hand, these findings contribute to the existing literature on urban sustainability and smartness understanding (USSU), since they reveal the environmental values, situational values, and psychological factors (Barr, 2007) which are important for the long-term and sustainable development of a developed city with a significant and increasing share of elderly persons. This seems especially relevant for urban planners since ageing cities will likely lead to future increases in the generation of hazardous waste, such as medicines.[11] On the other hand, given the increasing importance of the paradigm of "circular economy", which consists of sustainable patterns of consumption and production entangling environmental quality, economic prosperity, and social equity for both present and future generations (Aljerf and Choukaife, 2016; Kirchherr et al., 2017; Martins et al., 2021), our results also provide relevant information for policymakers. This study shows to what extent cultural values, revealed by variables such as the spatial location of households or their age composition, are importantly correlated with a pro-environmental consumer's decision making. Furthermore, the proven importance of making households more environmentally aware stresses the importance of circular public procurement. That is, providing individuals with better information on the economic and moral cost of excessive water consumption and improper waste disposal, by means of public authorities purchasing nudging services at the same time environmental impacts and waste generation are minimized (EU Commission, 2017).

In sum, the LCM methodology applied in this study allows us to sort households according to their degree of pro-environmental behavior. Implementing public policies based on the characteristics of individuals will help to achieve long-term changes in their environmentally friendly habits. We should note that this paper presents some shortcomings that offer a useful starting point for further research. First, the empirical analysis has been carried out considering residential waste as if it were a homogeneous entity. Thus, the next step would be to carry out a study considering different types of waste (glass, plastic, e-waste, batteries, etc.). Since proper waste management is essential to minimize its environmental impact, this analysis would allow us to explore different waste disposal options, assessing their viability and environmental impact. Additionally, it would also allow us to characterize waste product profiles, identifying materials that can be recovered and recycled in urban contexts.

Second, analyzing energy consumption associated with recycling as well as the CO_2 emissions generated by these activities presents an interesting strand of research. Identifying the activities associated to high energy consumption and carbon emissions would give us the possibility to propose measures aimed at reducing the environmental footprint of recycling, promoting the use of cleaner and more efficient technologies. Finally, in order to move towards more sustainable water management, it would be interesting to complement this work with an assessment of the potential of water reuse and recycling. This would help to identify which recycling technologies and practices can help to reduce dependence on fresh natural resources and contribute to a more closed and sustainable water cycle.

CRediT authorship contribution statement

Marian García-Valiñas: Conceptualization, Methodology, Formal analysis, Writing – original draft, Writing – review & editing. **Fernando Arbués:** Conceptualization, Formal analysis, Writing – original draft, Writing – review & editing. **Roberto Balado-Naves:** Writing – original

[11] 80% of the EU population over 65 years old consume medicines (Eurostat, 2022), and a high proportion of adults aged 75 and older regularly take at least 5 different medications per day (OECD, 2021).

draft, Writing – review & editing.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

The data that has been used is confidential.

Acknowledgements

The authors would like to thank the European Commission and the Spanish Ministry of Science, Innovation and Universities for funding in the frame of the collaborative international consortium NEWTS financed under the 2018 Joint call of the WaterWorks 2017 ERA-NET Cofund (MCIU-19-PCI2019-103676). This ERA-NET is an integral part of the activities developed by the Water JPI. We also thank the support provided by the Departamento de Ciencia, Universidades y Sociedad del Conocimiento del Gobierno de Aragón (project S23_20R, Grupo de Investigación de Economía Pública).

APPENDIX

Table A1
Questions related to recycling habits

P.43 Which of the following do you recycle (you can choose several answers):	P.44 Have you made use of designated waste collection points or household collection services for disposing of the following (you can choose several answers):
1) Glass	1) Small electric appliances (microwaves, irons, etc.)
2) Plastics and packaging	2) Electronic devices (laptops, mobile phones, etc.)
3) Paper and cardboard	3) Furniture
4) Organic waste (to produce compost and biogas)	4) I have not needed to dispose of anything
5) Used oil	5) I'm not sure
6) Batteries	
7) Medication/drugs	
8) I don't usually recycle	

Table A2
Questions related to water habits. P.21. In general, has your household adopted any of the following habits to reduce water consumption?

	No	Yes
Recycling water. For example, making use of water from the shower while waiting for it to warm up		
Keeping a bottle of cold water in the fridge so as not to leave the cold water running from the tap		
Turning off the tap while applying soap to your hands		
Thawing food in advance instead of thawing it under the tap		
Filling the sink before washing the dishes		
Waiting until the dishwasher and the washing machine are full before running them		
Tightening the shut-off valve to decrease the flow from the tap		
Not using the toilet as a rubbish bin, avoiding throwing all types of waste into it		
Making use of the partial-flush system on the toilet tank to select the quantity of water		
Turning off the tap while brushing your teeth		
Taking showers instead of baths		
Turning off the shower while applying soap		
Avoiding washing your car with water from the drinking water supply		

Table A3
Type and quantity of waste admitted at waste and recycling drop-off centers

ADMITTED WASTE	MAX QUANTITY	ADMITTED WASTE	MAX QUANTITY
Mineral/synthetic oil	10 L	Containers	No limit
Oil filters	5 units	Glass (bottles)	No limit
Tyres	4 units	Residential vegetal oil	No limit
Lead batteries	2 units	Clothes and textiles	No limit
Empty oil/gasoline containers	5 units	Paints/solvents	20 L
Absorbents/contaminated material/rags	10 L	Solvents and aerosols	10 units
Hydraulic oil	1 L	Radiographies	10 units
Appliances	2 units	Toner/printer cartridges	10 units
Fridges	2 units	Drugs	50 units
Electronic scrap	5 units	Mercury thermometers	2 units
Televisions	2 units	Discs, DVDs, cassettes, VHS	50 units
Low consumption lamps	5 units	Packages with hazardous remnants	5 units
Neon	5 units	Photographic liquids	10 L
Standard batteries	50 units	Natural wood	20 units
Button cell	50 units	Chipboard	20 units
Mobile phones	No limit	Metals	No limit
Mixed debris	120 L	Aluminium and copper	No limit
Selected debris	120 L	Plastic/EPS/Packages	No limit

(*continued on next page*)

Table A3 (*continued*)

ADMITTED WASTE	MAX QUANTITY	ADMITTED WASTE	MAX QUANTITY
Furniture	20 units	Plant waste	1 m3/day and 4 m3/month
Mattresses	5 units		
Coffee containers	No limit	Paper/cardboard	No limit

Source: Elaborated by the authors with data from EMULSA.

References

Aitkin, M., Rubin, D.B., 1985. Estimation and hypothesis testing in finite mixture models. J. R. Statistical Soc. Series B: Statistical Methodol. 47 (1), 67–75.

Aljerf, L., Choukaife, A.E., 2016. Sustainable development in Damascus University: a survey of internal stakeholder views. J. Environ. Stud. 2 (2), 1–12.

Alvarado, J.M., Torres, W.I., Aguirre, N.I., Ochoa-Moreno, W.S., 2021. Water saving practices conditioned by socioeconomic factors: a case study of Ecuadorian households. J. Environ. Manag. 293, 112818 https://doi.org/10.1016/j.jenvman.2021.112818.

Anderson, D.J., Krettenauer, T., 2021. Connectedness to nature and pro-environmental Behaviour from early adolescence to adulthood: a comparison of urban and rural Canada. Sustainability 13, 3655. https://doi.org/10.3390/su13073655.

Antunes, L.N., Ghisi, E., 2020. Water and energy consumption in schools: case studies in Brazil, Environment. Development and Sustainability 22, 4225–4249. https://doi.org/10.1007/s10668-019-00380-x.

Aprile, M.C., Fiorillo, D., 2019. Intrinsic incentives in household waste recycling: the case of Italy in the year 1998. J. Clean. Prod. 227, 98–110. https://doi.org/10.1016/j.jclepro.2019.04.184.

Arbués, F., Villanúa, 2016. Determinants of behavior toward selective collection of batteries in Spain. A bivariate probit model, Resources, Conservation and Recycling 106, 1–8. https://doi.org/10.1016/j.resconrec.2015.11.004.

Arbués, F., Villanúa, I., 2022. Why do Spanish households separate their e-waste for proper disposal? An econometric analysis. Environ. Sci. Pollut. Control Ser. 29, 7185–71201. https://doi.org/10.1007/s11356-021-15933-9.

Barr, S., 2007. Factors influencing environmental attitudes and behaviors: a UK case study of household waste management. Environ. Behav. 39 (4), 435–473.

Barr, S., Gilg, A., Ford, N., 2001a. A conceptual framework for understanding and analysing attitudes towards household-waste management. Environ. Plann. 33, 2025–2048. https://doi.org/10.1068/a33225.

Barr, S., Gilg, A., Ford, N., 2001b. Differences between household waste reduction, reuse and recycling Behaviour: a study of reported behaviours, intentions and explanatory variables. Environ. Waste Manag. 4 (2), 69–80.

Barr, S., Gilg, A., Ford, N., 2005. Defining the multi-dimensional aspects of household waste management: a study of reported behavior in Devon, Resources. Conserv. Recycl. 45, 172–192. https://doi.org/10.1016/j.resconrec.2004.12.007.

Beaumais, O., Prunetti, D., 2018. Time for waste, waste of time? Assessing heterogeneous values of saving time from recycling. Rev. Écon. Polit. 128, 915–934. https://doi.org/10.3917/redp.285.0915.

Cameron, A.C., Trivedi, P.K., 2005. Microeconometrics: Methods and Applications. Cambridge University Press, New York.

Casazza, M., Xue, J., Du, S., Liu, G., Ulgiati, S., 2021. Simulations of scenarios for urban household water and energy consumption. PLoS One 16 (4), e0249781. https://doi.org/10.1371/journal.pone.0249781.

Costa, L., Ghisi, E., Fonseca, D., Marcon, G., 2011. Potential for electricity savings by reducing potable water consumption in a city scale. Resour. Conserv. Recycl. 55, 960–965. https://doi.org/10.1016/j.resconrec.2011.05.003.

Czajkowski, M., Hanley, N., Nyborg, K., 2017. Social norms, morals and self-interest as determinants of pro-environment behaviours: the case of household recycling. Environemntal and Resource Economics 66, 647–670. https://doi.org/10.1007/s10640-015-9964-3.

Dieu-Hang, T., Grafton, R.Q., Martínez-Espiñeira, R., Garcia-Valiñas, M., 2017. Household adoption of energy and water-efficient appliances: an analysis of attitudes, labelling and complementary green behaviours in selected OECD countries. J. Environ. Manag. 197, 140e150. https://doi.org/10.1016/j.jenvman.2017.03.070.

Dworak, T., Berglund, M., Laaser, C., Strosser, P., Roussard, J., Grandmougin, B., Kossida, M., Kyriazopoulou, I., Berbel, J., Kolberg, S., Rodriguez-Diaz, J.A., Montesinos, P., 2007. EU Water Saving Potential (Part 1 –Report). ENV.D.2/ETU/2007/0001r. Ecologic, Institute for International and European Environmental Policy, Berlin.

EEA, 2021. Water Resources across Europe — Confronting Water Stress. An Updated Assessment, European Environment Agency. Report 12/2021.

EMA, 2020. Memoria de Responsabilidad Corporativa 2020. Empresa Municipal de Aguas de Gijón S.A.U. https://drupal.gijon.es/sites/default/files/2022-01/2020_Memoria_EMA.pdf.

EMULSA, 2022. Memoria de sostenibilidad 2022 y memoria económica EMULSA. Empresa municipal de servicios de medio ambiente urbano de Gijón, S.A.. https://drupal.gijon.es/sites/default/files/2023-08/MEMORIA%20DE%20SOSTENIBILIDAD%202022%20Y%20MEMORIA%20ECON%C3%93MICA%20EMULSA%20VERIFICADA.pdf.

EU Commission, 2017. Public procurement for a circular economy: good practice and guidance. Available at: http://ec.europa.eu/environment/gpp/pdf/Public_procurement_circular_economy_brochure.pdf.

Eurostat, 2022. Self-reported use of prescribed medicines by sex, age and educational attainment level. https://ec.europa.eu/eurostat/databrowser/view/HLTH_EHIS_MD1E_custom_6616402/default/table?lang=en. (Accessed 20 June 2023).

Fernandez-Blanco, V., Orea, L., Prieto-Rodriguez, J., 2009. Analyzing consumers heterogeneity and self-reported tastes: an approach consistent with the consumer's decision making process. J. Econ. Psychol. 30, 622–633.

Fielding, K.S., Russell, S., Spinks, A., Mankad, A., 2012. Determinants of household water conservation: the role of demographic, infrastructure, behavior, and psychosocial variables. Water Resour. Res. 48 (10).

Fiorillo, D., Sapio, A., 2019. Energy saving in Italy in the late 1990s: which role for non-monetary motivations? Ecol. Econ. 165, 106386 https://doi.org/10.1016/j.ecolecon.2019.106386.

García, J.L.C., Martín-Sevillano, R., Sánchez-Gómez, M.C., Martín-Cilleros, M.V., Verdugo-Castro, S., Mena, J., Álvarez, V.I., 2022. January). A qualitative study and analysis on the use, utility, and emotions of technology by the elderly in Spain. In: *World Conference on Qualitative Research*. Springer International Publishing, Cham, pp. 248–263.

Gilg, A., Barr, S., 2006. Behavioural attitudes towards water saving? Evidence from a study of environmental actions. Ecol. Econ. 57, 400–414. https://doi.org/10.1016/j.ecolecon.2005.04.010.

Gilg, A., Barr, S., Ford, N., 2005. Green consumption or sustainable lifestyles? Identifying the sustainable consumer. Futures 37, 481–504. https://doi.org/10.1016/j.futures.2004.10.016.

Gillingham, K., Tsvetanov, T., 2018. Nudging energy efficiency audits: evidence from a field experiment. J. Environ. Econ. Manag. 90, 303–316. https://doi.org/10.1016/j.jeem.2018.06.009.

Hornik, J., Cherian, J., Madansky, M., Narayana, C., 1995. Determinants of recycling behavior: a synthesis of research results. J. Soc. Econ. 24 (1), 105–127.

Howard, G., Bartram, J., Williams, A., Overbo, A., Fuente, D., Geere, J.A., 2020. Domestic Water Quantity, Service Level and Health, second ed./. World Health Organization, Geneva.

INE, 2021. Encuesta Continua de Hogares (ECH), nota de prensa. Instituto Nacional de Estadística. https://www.ine.es/prensa/ech_2020.pdf.

Jin, Y., Tang, X., Feng, C., Höök, M., 2017. Energy and water conservation synergy in China: 2007–2012, Resources. Conserv. Recycl. 127, 206–215. https://doi.org/10.1016/j.resconrec.2017.09.004.

Kheirinejad, S., Bozorg-Haddad, O., Singh, V.P., Loáiciga, H.A., 2022. The effect of reducing per capita water and energy uses on renewable water resources in the water, food and energy nexus. Sci. Rep. 12 (1), 7582. https://doi.org/10.1038/s41598-022-11595-w.

Kirchherr, J., Reike, D., Hekkert, M., 2017. Conceptualizing the circular economy: an analysis of 114 definitions. Resour. Conserv. Recycl. 127, 221–232.

Kumar, P., Caggiano, H., Cuite, C., Andrews, C.J., Felder, F.A., Shwom, R., Floress, K., Ahame, S., Schelly, C., 2022. Behaving or not? Explaining energy conservation via identity, values, and awareness in U.S. suburban homes. Energy Res. Social Sci. 92, 102805 https://doi.org/10.1016/j.erss.2022.102805.

Liobikienė, G., Minelgaitė, A., 2021. Energy and resource-saving behaviours in European Union countries: the Campbell paradigm and goal framing theory approaches. Sci. Total Environ. 750, 141745 https://doi.org/10.1016/j.scitotenv.2020.141745.

Liu, Y., Kua, H.W., Lu, Y., 2021. Spillover effects from energy conservation goal-setting: a field intervention study, Resources. Conserv. Recycl. 170, 105570 https://doi.org/10.1016/j.resconrec.2021.105570.

Maier, J., Palazzo, J., Geyer, R., Steigerwald, D.G., 2022. How much potable water is saved by wastewater recycling? Quasi-experimental evidence from California, Resources. Conserv. Recycl. 176, 105948 https://doi.org/10.1016/j.resconrec.2021.105948.

March, H., Hernández, M., Saurí, D., 2015. Assessing domestic water use habits for more effective water awareness campaigns during drought periods: a case study in Alicante, eastern Spain. Nat. Hazards Earth Syst. Sci. 15, 963–972. https://doi:10.5194/nhess-15-963-2015.

Martins, L.S., Guimarães, L.F., Junior, A.B.B., Tenório, J.A.S., Espinosa, D.C.R., 2021. Electric car battery: an overview on global demand, recycling and future approaches towards sustainability. J. Environ. Manag. 295, 113091.

Massarutto, A., Marangon, F., Troiano, S., Favot, M., 2019. Moral duty, warm glow or self-interest? A choice experiment study on motivations for domestic garbage sorting in Italy. J. Clean. Prod. 208, 916–923. https://doi.org/10.1016/j.jclepro.2018.10.140.

Nainggolan, D., Pedersen, A.B., Smed, S., Zemoa, K.H., Haslera, B., Termansenb, M., 2019. Consumers in a circular economy: economic analysis of household waste sorting Behaviour. Ecol. Econ. 166, 106402 https://doi.org/10.1016/j.ecolecon.2019.106402.

OECD, 2021. Health at a Glance 2021: OECD Indicators. OECD Publishing, Paris. https://doi.org/10.1787/ae3016b9-en.

Official State Gazette, 2022. Law 7/2022 of 8 April on Waste and Contaminated Soils for a Circular Economy. https://www.boe.es/buscar/act.php?id=BOE-A-2022-5809.

Oskamp, S., Burkhardt, R.L., Schultz, P.W., Hurin, S., Zelezny, L., 1998. Predicting three dimensions of residential curbside recycling: an observational study. J. Environ. Educ. 29 (2), 37–42. https://doi.org/10.1080/00958969809599111.

Pausas, J.G., Millán, M., 2019. Greening and browning in a climate change hotspot: the Mediterranean Basin. Bioscience 69, 143–151. https://doi.org/10.1093/biosci/biy157.

Pérez-Urdiales, M., García-Valiñas, M.A., 2016. Efficient water-using technologies and habits: a disaggregated analysis, in the water sector. Ecol. Econ. 128, 117–129. https://doi.org/10.1016/j.ecolecon.2016.04.011.

Pirani, E., Secondi, L., 2011. Eco-friendly attitudes: what European citizens say and what they do. Int. J. Environ. Res. 5 (1), 67–84.

Royne, M.B., Levy, M., Martinez, J., 2011. The public Helath implications of consumers' environmental concern and their willingness to pay for an eco-friendly product. J. Consum. Aff. 45, 329–343. https://doi.org/10.1111/j.1745-6606.2011.01205.x.

Sanguinetti, A., McIlvennie, C., Pritoni, M., Schneider, S., 2022. Two (or more) for one: identifying classes of household energy- and water-saving measures to understand the potential for positive spillover. PLoS One 17 (7), e0268879. https://doi.org/10.1371/journal.pone.0268879.

Smiley, K.T., Chen, Y.A., Shao, W., 2022. Being green in a green capital: assessing driverso of pro-environmental behaviors in Copenhaguen. Cities 122, 103538. https://doi.org/10.1016/j.cities.2021.103538.

Steel, B.S., 1996. Thinking globally and acting Locally?: environmental attitudes, behavior and activism. J. Environ. Manag. 47, 27–36.

Thiam, D.R., Dinar, A., Ntuli, H., 2021. Promotion of residential water conservation measures in South Africa: the role of water-saving equipment. Environ. Econ. Pol. Stud. 23, 173–210. https://doi.org/10.1007/s10018-020-00286-3.

UN, 2015. The 2030 Agenda for Sustainable Development, Resolution Adopted by the General Assembly on 25 September 2015.

UN, 2022. The sustainable development Goals report 2022. Available at: https://unstats.un.org/sdgs/report/2022/The-Sustainable-Development-Goals-Report-2022.pdf.

Union, European, 2018. Directive 2018/851 of the European Parliament and of the Council of 30 May Amending Directive 2008/98/EC on Waste. https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=uriserv:OJ.L_.2018.150.01.0109.01.ENG.

Wedel, M., DeSarbo, W.S., Bult, J.R., Ramaswamy, V., 1993. A latent class Poisson regression model for heterogeneous count data. J. Appl. Econom. 8 (4), 397–411.

Yang, C., Arhonditsis, G.B., 2022. What are the primary covariates of environmental attitudes and behaviours in Canada? A national-scale analysis of socioeconomic, political, and demographic factors. Ecol. Inf. 69, 101661.

Yuan, Y., Takahashi, Y., Yabe, M., 2015. Preferences for the attributes of household Kitchen waste source separation services in China using latent class approach. J. Fac. Agric. Kyushu Univ. 60 (2), 511–518. https://doi.org/10.5109/1543422.

Zhu, J., Zhao, X., Zhu, T., Li, L., 2021. Which factors determine students' water-saving behaviors? Evidence from China colleges. Urban Water J. 18 (10), 860–872. https://doi.org/10.1080/1573062X.2021.1943459.