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Perception welfare assessment of water reuse in competitive categories

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ABSTRACT

The supply of reclaimed water to ecosystems increases their ecosystem service flows, which is directly translated into terms of social welfare. This study explores the factors that determine the different perceptions of the welfare impact of supplying reclaimed water to different, and competitive, ecosystems in the Segura River Basin (southern Spain): specifically, an agroecosystem (agricultural irrigation) and a river (higher river flow). The results of a contingent valuation exercise with the population of the Murcia Region show four different groups of respondents, depending on their willingness to pay (WTP) preferences. The factors that identify differences among welfare impacts are the age, the gender, the education level, the monthly income, the nearness of the household to the river, and, above all, the degree of satisfaction with funding of water reclamation. This study broadens our knowledge of individuals' heterogeneous preferences in water reuse options, which is crucial for policy makers in the development of socially accepted and sustainable water resource management strategies.

Key words | agroecosystem, contingent valuation, ecosystem services, Segura River Basin, sociodemographic characteristics, Spain

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INTRODUCTION

Recycling, reusing, and reclaiming wastewater are sustainable alternatives to deal with water scarcity and face up to increasing water demands (Garcia-Cuerva *et al.* 2016). Thus, reclaimed water could be seen as an effective alternative to overcome droughts in water-scarce regions (Pereira *et al.* 2002), due to the fact that it can be used in industry (Sanz *et al.* 2015), agriculture (Pedrero *et al.* 2010), and urban applications (Kandiah *et al.* 2016). Also, reclaimed water can be used for environmental purposes, such as recovering river flow (Martínez-Paz *et al.* 2014) or aquifer recharge (Birol *et al.* 2010).

The supply of reclaimed water to an ecosystem (i.e. forest, agricultural, wetland, or river ecosystems) contributes to its provision of ecosystem services (Engel & Schaefer 2013): production of goods and services (i.e. food, timber, or recreational activities), development of biodiversity, and, above all, improvement of their ecological status. Therefore, ecosystem services can be used as a framework to assess the overall contribution of the reclaimed water to the ecosystems. In this sense, ecosystem services are the benefits that people obtain from ecosystems (MEA 2005). The supply of reclaimed water to the ecosystems may be translated into terms of social welfare. Thus, the management of reclaimed water use involves not only economic and environmental concerns, but also social ones.

Although social welfare is promoted by supplying reclaimed water to ecosystems, not all social benefits are perceived equally by society. Water reuse program

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implementations usually encounter problems due to public resistance (Rock *et al.* 2012). In this way, guaranteeing the public acceptability of a reclamation program should be an essential purpose of water policy in order to get long-term stability. The improvement of information about public perceptions is a priority for policy makers to be able to analyse different water reuse options and assess the most sustainable water management strategy (Garcia-Cuerva *et al.* 2016).

In this context, this paper focuses on determining the factors that explain the differences in welfare perception when considering the supply of reclaimed water to different, and competitive, ecosystems in the Segura basin (southern Spain): namely, an agroecosystem (agricultural irrigation) and a river (getting a greater river flow). To this end, analysis of variance (ANOVA) and Pearson's chi-square test of independence were applied to the results of a contingent valuation exercise. The contingent valuation allowed the determination of the value of the global ecosystem services provision of the reclaimed water in the two ecosystems, which may be understood as the social welfare provided. In this way, differences in welfare valuation between the two competitive ecosystems were used to explore the differences in welfare perception according to the sociodemographic characteristics of the people surveyed and their relationship with these ecosystems.

To date, a relevant number of empirical studies have analysed the level of public acceptance of using reclaimed water, i.e. Ahmad (1991), Robinson *et al.* (2005), Hartley (2006), Dolnicar *et al.* (2011), Rock *et al.* (2012), and Garcia-Cuerva *et al.* (2016). However, most of them just focused on the qualitative differences in public perceptions of reclaimed water reuse, and did not take welfare perception into account in a quantitative way. Besides, the number of empirical works related to the valuation of the social benefit of reusing wastewater is limited and centred on estimating the non-market benefits of the implementation for only one water reuse option (Menegaki *et al.* 2007; Birol *et al.* 2010; Martínez-Paz *et al.* 2014). But none of these studies analysed the trade-off between two or more reclaimed water reuse alternatives.

Considering the insufficient discussion found in the literature, this paper contributes to broadening information and knowledge about the relationships among three main issues: reclaimed water, welfare perception, and ecosystem services. Studies about ecosystem services in the context of reusing reclaimed water are sparse. Engel & Schaefer (2013) and Garcia *et al.* (2016) analysed, in theoretical terms, the provision of the different kinds of ecosystem services due to the supply of reused water, but forgot about its impact on social welfare. Furthermore, this study adds to the debate about considering heterogeneous preferences in the implementation of alternative water policies, especially in the setting of socially accepted water tariffs.

METHODS

Case study description

The study is based in the Murcia Region, within the Segura River Basin (southern Spain). This basin has the third highest level of water stress in Europe (EEA 2009). In this basin, reclaimed water is 8% of annual water supply (HPSD 2016). Among other uses, agricultural irrigation consumes more than 50% of the total reclaimed water (ESAMUR 2018) and environmental uses, especially recovery of the river flow, represent 42% (HPSD 2016). The treatment operation costs are currently paid by the domestic water consumers through a 'treatment charge' following the polluter pays principle. Urban users pay in accordance with their domestic water consumption, 6€/household being the monthly average treatment charge, which is added to their current water bill.

Water reuse categories

The Reuse of Purified Wastewaters Act (RPWA) (BOE 2007) determines the legal framework for the reuse of reclaimed water in Spain. According to it, water reuse is defined as the new private use of water, after having undergone a treatment process for its purification and before being returned to the public domain. Similarly, reclaimed water is understood as water rendered fit for reuse.

The RPWA establishes 24 different applications for reclaimed water, gathered around five main categories: urban, industrial, recreational, agricultural and environmental (BOE 2007). According to this classification, water reuse is allowed for the following applications: private garden watering, the discharge of sanitary appliances, the irrigation of urban green areas, street and car washing, fire-fighting systems [urban uses]; process and cleaning water in industry, refrigeration towers and evaporation condensers [industrial uses]; the irrigation of golf courses, and for ponds, bodies of water and running water with no public access [recreational uses]. In the case of water reuse for agricultural purposes, its use depends on the kind of crop, distinguishing three different applications depending on the direct contact of the reclaimed water with edible parts of food, and its consumption as fresh food. Finally, the environmental applications encompass uses such as recharge of aquifers, the irrigation of forests and green zones with no public access, and other uses, including the maintenance of wetlands or minimum stream flows. In this way, water reuse is forbidden for human consumption, specific uses of the food industry, hospital installations, and swimming waters, among other uses.

The RPWA also determines qualitative and quantitative parameters (intestinal nematode eggs, *Escherichia coli*, suspended solids and turbidity) that define the quality criteria of reclaimed water for all reuse applications, except for the maintenance of wetlands and minimum flows (Iglesias *et al.* 2010). So, this study allows an analysis of the social demand of using a tertiary treatment for water reclamation, which ensures a quality level that is suitable for both ecosystems considered here and goes beyond the current wastewater treatment in the region.

In this context, this paper is focused on the last two water reuse categories, namely agricultural irrigation and getting a higher river flow, which refers to the agricultural and river ecosystems, respectively. These categories were selected due to their importance as the main water reuse categories in the region, and in order to shed light on the existing social conflict between both uses of water (Perni & Martínez-Paz 2017).

Data collection

Data were collected through a survey consisting of a combination of 18 open- and close-ended questions. The questionnaire was designed after expert consultations, focus-group discussions, and three rounds of pre-testing. The questions were grouped in three parts, which covered the respondents' relationship with the Segura River ecosystem, their knowledge of the current status of reclaimed water reuse, and their valuation of the welfare impact of reusing treated water in both ecosystems. It also included sociodemographic information on the respondents.

The survey was conducted in October 2008 by trained enumerators, with a random sample of 352 respondents. The target population was the households of the Murcia Region (378,252 households). The survey had an associated sampling error of 5% at a 95% confidence level.

Valuation exercise

Most ecosystem services do not have a real market which could reflect their price as a proxy of their value. This is a traditional issue in the context of environmental economics. Stated preference methods, such as contingent valuation, try to solve it by establishing a hypothetical market where people can declare their demand for these kinds of un-priced services through their willingness to pay (WTP).

The social benefits of reusing reclaimed water in the agricultural ecosystem include the non-market value of increasing the production of food, related to the provisioning services; the value of reducing the pressure on freshwater extraction, which refers to the regulating services; and the social effects of employment in agriculture, as cultural services. In the case of the river ecosystem, the social benefits comprise the value of increasing the flora and fauna, the value related to ensuring a good ecological status of the river, and the impact of increasing recreational activities along the river, which are referred to as provisioning, regulating, and cultural services, respectively.

The contingent valuation method was introduced in the questionnaire through an open-ended question in order to establish the effective amount of money that the respondents were willing to pay; that is, their monetary WTP (MWTP). The MWTP indicates how changes in the provision level of ecosystem services impact on individual welfare. Aggregating the welfare scores for all those individuals who are impacted by the changes in the provision of ecosystem services provides an indicator of the total social welfare. For detail about WTP estimation, see Alcon *et al.* (2010; 2012).

Sociodemographic factors and relationship with the Segura River and reclaimed water

The following socioeconomic and demographic variables were measured: age, gender, education level, household size, and monthly income.

In order to determine the respondents' relationships with the ecosystems and reclaimed water, they were asked about their direct and indirect uses of the Segura River, their knowledge of the uses of reclaimed water in the study area, and their point of view regarding the allocation of the money they paid to water reclamation. In particular, each respondent's place of residence was translated into a dummy variable reflecting nearness to the Segura River. The number of times that the respondents visit the Segura River was employed as an approximation of the direct use of the river. The knowledge of the fact that reclaimed water is supplied to the Segura River was also analysed.

A total of four close-ended questions were developed to reveal the respondent's perception of their current contribution to the financing of water reclamation. Specifically, the questions asked whether the respondents were aware that the water reclamation cost is included in their water bill and whether they knew that this cost was, on average, 6€/month and household. To contextualize the respondents in their own situation, the total cost of their water bill was also queried. Finally, the respondents were asked if they were satisfied with paying around 6€/month to improve the water quality of the river.

Statistical analysis

In order to determine the sociodemographic and behavioural factors that may explain the differences in welfare perception, ANOVA was used to analyse continuous variables, and Pearson's chi-square test of independence was used for categorical variables. The groups to compare were defined according to the MWTP variable. If the null hypothesis of the ANOVA was rejected, the Tukey–Kramer pairwise comparison test was applied. To guarantee the consistency of the ANOVA results, it was proved that the sample was homoscedastic and normally distributed, through the Levene and Shapiro–Wilk tests, respectively. According to Pearson's chi-square test, if the null hypothesis is rejected, there is a dependence relationship between them, and so, post-hoc tests are developed.

RESULTS AND DISCUSSION

Sample description

The respondents were, on average, slightly more than 40 years old, females constituting 46% of the sample. Regarding income, nearly 60% of the respondents in the sample earned less than 1,600€ per month. No significant differences were found in terms of age, gender, income, or household size between the sample and the general population.

The variables which summarize the respondents' knowledge of and attitudes towards water reclamation show that more than three-quarters of the sample lived near the Segura River. This explains why the share of direct and indirect users of reclaimed water was relatively high. Two-thirds of the respondents knew that reclaimed water is supplied to the Segura River on its path through Murcia City, but only half of them knew that its cost is assumed by urban water users. Furthermore, almost half of the sample was satisfied with paying for water reclamation in order to improve river water flow and quality.

Willingness to pay categories

The results of the contingent valuation exercise revealed that 71% of the respondents were willing to pay for the supply of reclaimed water to agriculture, while reusing it in the Segura River was supported by 79%. So, more than three-quarters of the sample, on average, recognized that reusing reclaimed water has an impact upon their individual welfare. The univariate analysis showed that, on average, people were willing to increase their monthly water bill by 5.26€/household (95% confidence interval: 4.34–6.18€/household) with the purpose of reusing reclaimed water in the agroecosystem. In the case of supplying reclaimed water to the river, the WTP averaged 5.43€/household (95% confidence interval: 4.54–6.31€/household) per month. These monthly values translate to 63.12€/household and 65.16€/household per year, respectively. Aggregated for the region as a whole (378,252 households),

Table 1 | DMWTP variable categories

Variable categories	Description	N	% Sample	MWTP river (€/household/month)	MWTP agroecosystem (€/household/month)
DMWTP	Respondents who are …				
$DMWTP_0$ (0)*	Not willing to pay	65	18.47	0.00	0.00
$DMWTP_R$ (M1)	Willing to pay more for reusing reclaimed water in the river ecosystem than for reusing in the agroecosystem	78	22.16	5.42	4.12
$DMWTP_A$ (M2)	Willing to pay more for reusing reclaimed water in the agroecosystem than for reusing in the river ecosystem	15	4.26	2.71	5.13
$DMWTP_B$ (M3)	Willing to pay the same for reusing reclaimed water in the river ecosystem and agroecosystem	194	55.11	5.53	5.53
		352	100.00		

*(·) variable code.

the social welfare associated with the improved provision of ecosystem services in the river ecosystem and agroecosystem due to reclaimed water reuse reaches an annual amount of 23.86€ and 24.65€ million, respectively.

In order to analyse the sociodemographic and individual factors which explain the differences between the WTP values of the agroecosystem and river ecosystem in terms of welfare perception, the sample was divided into four different categories according to the results of the WTP survey. The conjoint analysis of the MWTP for the reuse of reclaimed water for the river ecosystem and agricultural purposes allowed us to study the intensity of the respondents in their welfare perception. To this end, a new classification of the sample was created (M class). Specifically, the sample was divided into those willing to pay more for reusing reclaimed water in the river than for reuse in agriculture (M1), those willing to pay more for supplying it to agriculture than for supplying it to the river ecosystem (M2), and those willing to pay the same for both reuse options (M3). The categorical variable 'DMWTP' condenses these sample groups (Table 1). The differences between categories according to the MWTP are statistically significant ($p < 0.01$).

Sociodemographic factors

The sociodemographic factors were tested for the significance of their relationships with the welfare valuation of supplying reclaimed water to the river and/or agroecosystem (Table 2).

The ANOVA results indicate that age had a significant influence on welfare perception ($p < 0.05$). Specifically, it had an impact on the decision of paying and on the amount of money that there was willingness to pay. That is, the older the respondents, the lower their WTP, and so the lower the impact of supplying reclaimed water to the ecosystem on their individual welfare. These outcomes are consistent with those obtained by Alcon *et al.* (2010, 2012). However, they contrast with other studies, such as Dolnicar *et al.* (2011) and Rock *et al.* (2012), who showed that age is related positively to public acceptance of the use of reclaimed water, or Menegaki *et al.* (2007), Gu *et al.* (2015), and Garcia-Cuerva *et al.* (2016), who did not find a relationship between these two parameters.

Females were willing to pay more for reusing reclaimed water in the river ecosystem than males. Thus, gender is a significant factor that explains the differences in MWTP ($p < 0.05$). Miller & Buys (2008) also found that gender has a significant relationship with public acceptance of the reuse of reclaimed water. In contrast, Robinson *et al.* (2005) did not find significant differences between males and females regarding different wastewater reuse options, except for groundwater recharge, women being less in favour of it. Menegaki *et al.* (2007) showed that gender did not have any influence on the WTP for agricultural products made with recycled water. Therefore, there is not a common consensus about how gender impacts on water reuse perception (Garcia-Cuerva *et al.* 2016).

Table 2 | ANOVA and Pearson's chi-square test of independence: results

Sociodemographic and individual factors	Total sample	DMWTP (0)	(M1)	(M2)	(M3)	*p*-value*
Total (%)	100.00	18.47	22.16	4.26	55.11	
Age (average)**	40.68	47.23a	38.83b	39.2b	41.35b	0.01
Gender (% female)	46.02	38.46a	62.82b	40.00ab	42.27a	0.01
Education (%)						
Primary education or lower	22.70	21.88a	23.38b	20.00b	22.92ab	0.03
Secondary education	36.78	51.56a	28.57b	13.33b	36.98ab	
Higher education	40.52	26.56a	48.05b	66.67b	40.52ab	
Monthly income (%)						
<1,000€	32.86	29.69a	37.66b	20.00ab	32.99ab	0.08
1,000–1,500€	26.29	14.06a	29.87b	40.00ab	27.84ab	
1,500–2,000€	14.86	17.19a	15.58b	6.67ab	14.43ab	
2,000–2,500€	12.57	15.63a	12.99b	20.00ab	10.82ab	
>2,500€	13.43	23.44a	3.90b	13.33ab	13.92ab	
Household size (average number of occupants)	3.40	3.53	3.31	3.20	3.40	0.67
Nearness to the Segura River (1 = Yes; 0 = No) (%)	75.57	87.69a	67.95b	73.33ab	74.74ab	0.05
Visits to the Segura River (1 = Yes; 0 = No) (%)	85.51	84.62	84.62	80.00	86.60	0.89
Visits to the Segura River (average)	85.74	89.63	108.30	38.08	79.53	0.22
Knowledge that… (1 = Yes; 0 = No) (%)						
The Segura River flow at Murcia City comes from reclaimed water	65.61	78.33	61.54	66.67	63.21	0.15
The cost of water reclamation is included in the water bill	52.31	69.49a	48.72b	53.33ab	48.45b	0.04
The average monthly wastewater treatment charge is 6€/household	15.27	18.33	12.82	26.67	14.43	0.49
How much is your water bill? (€ average)[b]	58.57	66.38	54.04	65.00	57.45	0.15
Are you satisfied with paying for water reclamation to improve river water quality? (1 = Yes; 0 = No) (%)	47.67	25.00a	40.26a	46.67ab	57.81b	0.00

*p-value refers to ANOVA in the case of numerical variables (age, household size, and total money paid in the monthly water bill) and to Pearson's chi-square test of independence in the rest of the variables.
**Different letters indicate significant differences among WTP categories.

Education level also influenced the WTP ($p < 0.10$). Especially, it distinguished those who were willing to pay from those who were not. Hence, respondents with lower education levels tended not to be willing to pay, while higher education levels were associated with a greater WTP to supply reclaimed water to the Segura River. This result supports previous findings (Hartley 2006; Gu *et al.* 2015; Garcia-Cuerva *et al.* 2016) and, especially, the work of Robinson *et al.* (2005), where significant differences in the perception of water reuse options according to the respondents' education level were shown.

Finally, monthly income was related to the MWTP ($p < 0.10$). According to the chi-square test results, lower income was associated with a higher WTP to reuse reclaimed water in the river. Other works, such as Hurlimann (2008) and Garcia-Cuerva *et al.* (2016), also found a link between individual income and the acceptability of water reuse.

The policy implications of the results comprise the establishment of new tools to improve the public acceptance of reclaimed water and, above all, to increase the perception of welfare impact. In this sense, third-degree price discrimination seems a good way to take into account the differences in WTP among individuals. It would be implemented through the treatment charge paid in the monthly water bill. For instance, age would be one of the variables that defined the different user segments, according to the results obtained here. Therefore, older people would pay a reduced treatment charge.

Relationship with the Segura River and reclaimed water

The location of the respondents influenced the welfare perception of supplying reclaimed water ($p < 0.10$). However, its influence was not as great as expected. In fact, proximity to the Segura River had a negative relationship with the welfare impact associated with supplying water to the river. Thus, 88% of the respondents who were not willing to pay actually lived near the Segura River, while, in the case of people who were willing to pay for supplying water only to the river, this share fell to around 69%. This implies that the public perception of the river's current ecological status was good, and so it is not necessary to improve the quality of the reclaimed water.

The knowledge of the fact that the cost of the reclaimed water is paid in the monthly water bill was found to be a significant factor ($p < 0.05$) that explained differences in WTP behaviour. To be exact, the more aware people were that they were paying this treatment charge, the less willing they were to pay. Distinguishing between ecosystems, respondents who were less aware that they were paying were willing to pay more for improvement of the water supplied to the river. Therefore, the water treatment cost was perceived as the disutility of supplying reclaimed water.

Above all, the most influential factor that determined the welfare perception of reclaimed water reuse was the degree of satisfaction with funding it ($p < 0.01$). As expected, people who were more satisfied with their current payment were more willing to pay.

CONCLUSIONS

These results should be useful in attempts to guarantee the public acceptance of water reuse policies, which are especially significant in regions of water scarcity. The social factors identified ought to be taken into account in order to improve the design and implementation of public awareness campaigns related to the importance of water reclamation in such regions.

Reclaimed water management should keep in mind the differences in welfare perception, with the objective of enhancing social welfare. Therefore, policy makers may distribute the public budget according to the results obtained here. In this sense, and due to the fact that citizens are more willing to fund the allocation of reclaimed water to environmental uses, public administrators may prioritize the maintenance of aquatic ecosystems taking into account that agricultural reuse is also highly valuated. For the specific case study, the WTP differences for both reclaimed water reuse options reveal that the indirect use (higher river flow) of reclaimed water should be funded 3% more than its direct use (agricultural irrigation) in order to promote the improvement of social welfare. This reflects the social importance of choosing correctly the most appropriate public policies.

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