A comprehensive cost analysis of reclaimed water production: Is it a financially viable resource for agricultural irrigation in southern Spain?

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Abstract

Although the use of reclaimed water for agricultural irrigation in Spain has been done since decades, till the drought period of 2005-2008 its use was not regulated. Since the entry into force of the Royal Decree 1620/2007, which established the legal regime for the reuse of treated water, the development of water reuse in Spain has experienced a significant growth. Nowadays, the current drought period 2022-2023 has brought the discussion to the political and social scenes, since conventional water sources are getting more scarce and expensive. Additionally, the EU regulation 2020/741 on the use of reclaimed water has entered into force in June 2023, setting strong quality requirements for reuse. This research aims to offer a comprehensive cost assessment of the reclaimed water production (i.e., tertiary treatment) upon the financial information gathered from different water treatment companies (both public and private) located on the Mediterranean coast of Andalusia. Results offer valuable information for policy makers, irrigators and water companies to design an adequate cost-recovery price setting in a regional context of increasing water scarcity and irrigation cuts due to a persistent drought event. Additionally, financial affordability of irrigators is also analyzed and discussed based on the economic water productivity of the crop mix in the region and the cost of alternative water sources, such as desalination.

Keywords: reclaimed water, cost-assessment, financial assessment, water scarcity, Southern Spain.

1. Introduction

Reclaimed water has become a significant non-conventional source of water for different uses, from industrial cooling to irrigation. This topic reaches special significance in water scarcity regions, such as Mediterranean countries, where water resources are generally overexploited and no water (of any source) should be wasted and lost to the sea (Hristov et al., 2021). Although the use of reclaimed water for agricultural irrigation in Spain has been done for decades, during the 2005-2008 drought period its use was regulated and promoted by the royal decree 1620/2007, which established the legal regime for the reuse of treated water (Iglesias et al., 2010). However, the high reuse goals set by some previous national plans have not materialized, and the expansion of the sector has been very limited in the last decades, as shown by Figure 1. According to data of the Spanish Association of Water Supply and Sanitation Companies (AEAS), the current treatment capacity at national level is 8,130 hm^3/year, while the volume of treated wastewater accounts for 4,097 hm^3/year. The Spanish National Institute of Statistics (INE) estimates a reuse of reclaimed water in Spain up to 507 hm^3/year, which, has practically remained constant at around 1.3 hm^3/day (507 hm^3/year) in the last 15 years (Figure 1), thus accounting for 12% of the treated volume.

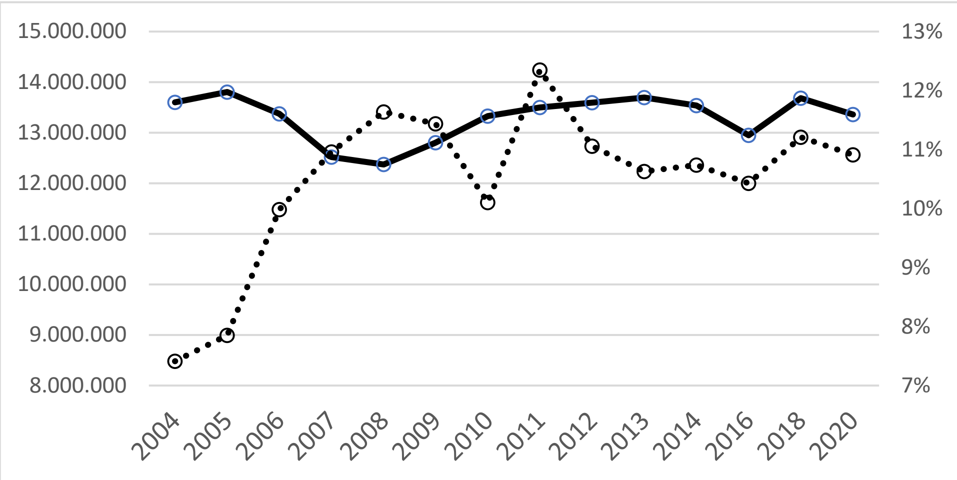

Figure 1. Reuse of reclaimed water in Spain (2004-2020) (m^3/day and % of treated volume). Source: Own elaboration.

The National Plan for Purification, Sanitation, Efficiency, Savings and Reuse (DSEAR Plan) is a governance instrument that aims to incorporate the reuse of reclaimed water in the third-cycle hydrological plans (2022-2027) in every river basin. From our point of view, probably the most relevant considerations are the following: 1) Encourage the use of reused water to release resources in water bodies subjected to significant pressure; 2) Eliminate institutional and financial barriers that limit the use of reused water, through the improvement of the regulatory and financial framework for reuse, and review and adaptation of RD 1620/2007 to the EU regulation 2020/741.

At national level, there are various organizational models to manage regenerated water resources, being of major relevance to characterize them the definition of property rights on the resource and the economic framework for its use. Regarding the definition of property rights, there are a wide variety of models from unlimited long-term private property (e.g., Australia), private property with certain limitations (e.g., USA, depending on the State), private concession limited in time (e.g., Spain, France, Portugal) or totally public property (e.g., Israel).

In the Spanish case, the basis of the model is the public concession, although there are different types of management models. Eventually, the owner of the 1st concession, usually an urban agent (or industrial), has authorization for the use that was originally granted, but can also request authorization for discharge to reuse. In this way, you can deliver the reclaimed water to irrigators in exchange for a price in order to cover the costs of the regeneration service. Alternatively, the irrigators (e.g., irrigation association) can request a public concession for the use of the regenerated water, assuming the costs and management of the tertiary treatment plant. Another option is when a public company, such as ESAMUR in the region of Murcia, assumes responsibility for 'more advanced' treatment for strategic reasons of local/regional interest. The cost of tertiary treatment is financed with regional funds and in some cases with a local contribution. In our opinion, this model will probably be extended if the reform proposal of Dir. 91/271, which makes tertiary treatment compulsory in municipalities with more than 100,000 inhabitants. In these cases, the tertiary service becomes the obligation of the local or regional operator and the cost of reclaimed water is integrated into the urban cycle. The water is discharged with a higher quality, thus reducing the cost to the irrigator (in the event that the irrigation association has a concession to use the discharges from the WWTP).

In the EU context, we can find two regulations with a high impact in the water reuse sector, the Regulation EU 2020/741 and the revision proposal of the Directive 91/271. The use of wastewater is limited by the need for adequate protection of health and the environment and requires a certain minimum quality of reclaimed treated water. The recently approved Regulation EU 2020/741 aims to open up market possibilities and opportunities. The Regulation introduces minimum requirements for the reuse of urban wastewater and requires the definition of risk management and transparency plans. Nevertheless, the real impact of regulation on the objectives of the circular economy is limited by water scarcity and crop profitability (Berbel et al., 2023). The regulation has entered into force in June 26th, 2023 without the need for legal transposition, so it is expected that Spanish government had concluded the adaptation requirements to ensure its full implementation.

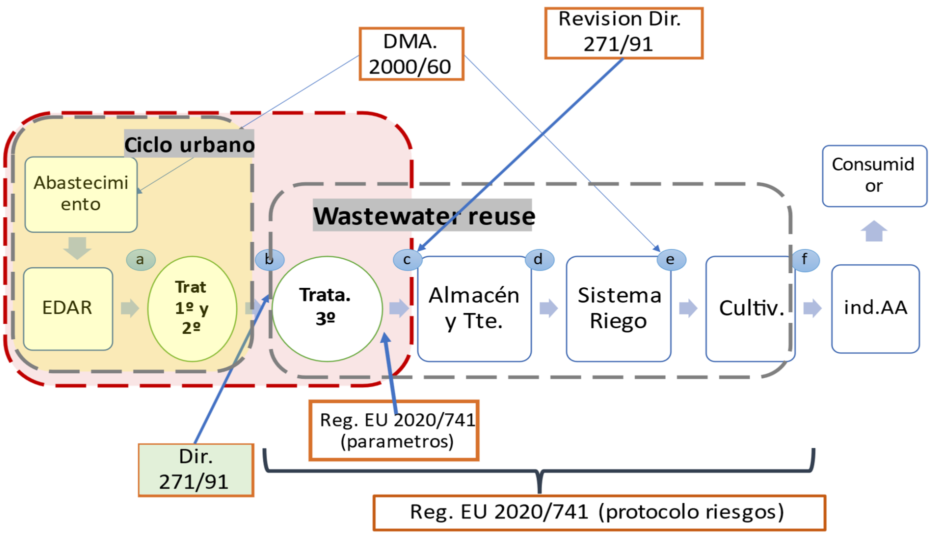

Figure 2. Water cycle and regulations in the EU context. Source: Own elaboration.

Figure 2 illustrates the regulatory system for the reuse of reclaimed water in all its phases. A recent study indicates that social acceptance is essential for the success of its implementation and therefore one of the requirements of the Regulation is the establishment of a risk plan and a quality assurance protocol. The European Commission has proposed technical guidelines for the application of key risk management principles linked to a water reuse system (Maffetone and Gawlik, 2022).

Regarding the recovery of costs, Figure 2 indicates that up to point 'b', which is the entrance to the regeneration facility or exit from the secondary treatment, the cost is assumed by the urban cycle that must be responsible up to the quality of discharge according to standard 91/271, while the tertiary would become the responsibility of the users (irrigators or others). However, the revision proposal of Dir. 91/271 can change this model as point 'c' would become the new frontier between the urban system and the user of reclaimed water. Therefore, tertiary treatment costs would be internalized by the urban cycle, thus lowering the cost to the end user of reclaimed water.

On the other hand, Directive 91/271 has been successfully implemented at the EU level, with 98% of urban water being treated, though there is still little or no treatment in small cities. After 30 years of application, work is being done on its revision and the EU Commission's proposal has important novelties in regard to the reuse of reclaimed water since, as indicated, the quality of the effluents and the internalization of costs of tertiary treatments would be changed. The specific proposal could have following impacts:

Table 1. Expected changes in the Directive 91/271/CEE on wastewater treatment in urban areas.

Type of treatment	Dir. 91/271	Revision proposal
Secondary	> 2,000 eq. inhab.	> 1,000 eq. inhab.
Tertiary	10,000 eq. inhab. Sensitive areas	> 100,000 eq. inhab. > 10,000 eq. inhab. Sensitive areas.

Quaternary	No	> 10,000 eq. inhab. Sensitive areas.

Source: Own elaboration.

The impact of this regulation could be more pronounced in urban agglomerations with equal to or greater than 100,000 equivalent inhabitants, where tertiary treatment becomes mandatory, so that the costs are internalized by the urban cycle and the cost at the exit of tertiary services would be zero. However, final users of reclaimed waters would still have to take charge of the management and costs of storage, transport and distribution.

Likewise, in smaller agglomerations that discharge into sensitive areas such as marine outfalls, the tertiary cost would be an extra cost that the end user should legally assume, unless the regional legislation, that is competent in this matter, requires a higher level of discharge quality, which in practice would imply the internalization of costs by the urban cycle.

Although the use of reclaimed water for irrigation has become a relevant issue in the current context of increasing water scarcity in Spain (and in southern Europe in general), few studies offer a comprehensive cost analysis of its production (Iglesias et al., 2010; Villar, 2016), and no study discusses the payment affordability of irrigators based on the water economic productivity of crops and the cost of alternative water sources. This research aims to offer a comprehensive assessment of the reclaimed water production (focusing on tertiary treatment) upon the financial and cost information gathered from different water treatment companies (both public and private) located on the Mediterranean coast of Andalusia. Results offer valuable information for policy makers, irrigators and water companies on an adequate cost-recovery price setting in the regional context of increasing water scarcity. Additionally, financial affordability of irrigators is also analyzed and discussed based on the water productivity of the crop mix in the region and the cost of alternative water sources, such as desalination.

It is worth noting that our analysis focuses on all operating costs of tertiary treatment, as a currently non-mandatory treatment in the urban cycle. Nevertheless, the EU regulation on water reuse establishes a quality standards for water reuse that require tertiary and advanced treatments if those resources are going to be used for irrigation. Currently, the costs of those treatments, if not regulated at national or regional level, must be assumed by the users of those non-conventional resources, that is the irrigators. Additionally, we must point out that amortization of investment is not considered in our analysis since it focuses on the marginal operating costs with the aim to offer useful information for a price setting scheme to sell this non-conventional resource to irrigators.

2. Case study and materials

The Andalusian Mediterranean Basins Demarcation (DHCMA) are the union of about 16 hydrological subsystems with a partial connection between them. In the DHCMA, the reuse of treated water has increased from 21 hm^3 in 2005 up to 27,4 hm^3 in 2015, with a foreseeable 47 hm^3 to be reached in 2023. Figure 3 shows the existing wastewater treatment plants (WWTP) with regeneration capacity and the planned facilities to be built in the period 2021 -2027. The use of resources from the El Bobar WWTP (Almería) for agricultural irrigation in Bajo Andarax and the systems built for irrigation in the Axarquía region (Málaga) are currently underway. On the Costa Tropical (Granada), the installation works of the Almuñécar WWTP are being completed to irrigate the crops of the irrigation communities of Río Verde de Jete, Almuñécar, and San Andrés. Additionally, the treatment plants equipped with tertiary treatment located in Roquetas de Mar, El Ejido and Adra are expected to provide reclaimed water for irrigation in Campo de Dalías (Almería). Finally, it should be mentioned that the incorporation of reclaimed water resources for agricultural irrigation in Bajo Guadalhorce (Málaga) is also planned.

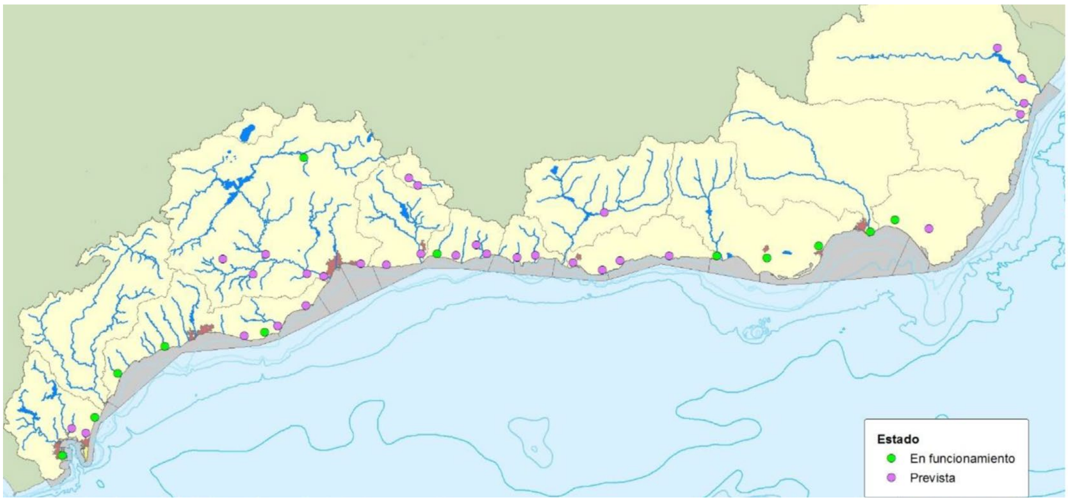

Figure 3. Location of WWTPs in the DHCMA.

This study takes the financial and cost information gathered from the main operating coastal WWTPs located in the DHCMA to analyze the operational costs of tertiary treatments. Data is referred to costs in year 2022. Additionally, this study takes into account the existence of economies of scale, with the aim to provide a accurate cost estimation of reclaimed water production (at different plant scales). This information on the investment costs in WWTPs in our case study has been obtained from the public construction budgets recently approved by the regional government (Junta de Andalucia and the DHCMA). Based on the economic water productivity estimated by several studies in regions of southern Spain, such as Calatrava and Martinez-Granados (2012) and Expósito and Berbel (2017), this study also offers a discussion on the payment affordability of irrigators of this non-conventional water source compared to alternative sources.

3. Cost assessment and estimation of economies of scale.

Based on the gathered financial information of the analyzed WWTPs in their tertiary treatment plants, a simulation of the operational costs for alternative production scales has been obtained (from 1 up to 10 hm^3 production scales). The propose cost scheme is composed by two components: a fixed cost component (considering the existence of economies of scale in the production) and variable cost component. The fixed cost is expressed in euros per year (EUR/year), what includes the cost associated to the installed energy power and the maintenance of the investment. The variable component is expressed in Euros per cubic meter (EUR/m^3) and it includes the rest of operational costs, including labor, energy consumption, chemical and consumable materials, among others. Our cost analysis considers two alternative scenarios, minimum and maximum, with the aim to include the variety of cost inputs reported by the water utilities operating the analyzed WWTPs.

3.1. Description of types of costs and assumed parameters.

This section describes the main information gathered from the financial and cost reports obtained from the analyzed WWTPs. Assumptions on the economies of scale present in the operating costs for different plant sizes and the cost parameters used for our scenario estimation are explained in detail.

Total investment of tertiary treatment

Total investment depends on the treatment capacity of the WWTP in its tertiary process. To estimate the existence of economies of scale, we have analyzed the building budgets of all tertiary WWTP in the DCMA in the years 2022-2023. Following logarithmic equation has been obtained to represent those economies of scale:

$$Investment\ \left(\frac{€}{m^3}\right) = 0{,}60 - 0{,}104\ \ln X\,;\ \ X = capacity\ \ h^3/year$$

This equation is used to estimate the unit investment cost for each treatment capacity from 1 to 10 hm^3. The analysis considers both, investments in equipment and building. Based on the investment information obtained from the building budgets of different WWTPs in our case study, we have consider an equal weight of 50% for building (construction) and equipment investments. Additionally, equipment investment considers mechanical (25% of equipment cost) and electronic equipment (25% of equipment cost). This investment parameters are considered constant in the two alternative cost scenarios.

As previously mentioned, amortization of investment is not considered in our analysis since it focuses on the marginal operating costs with the aim to offer useful information for a price setting scheme to sell this non-conventional resource to irrigators.

Fixed-cost component

Based on the gathered production data, it is assumed that installed energy power is 135 kW in the case of 10 hm^3 and 50 kW in the case of 1 hm^3. Economies of scale are considered between these two extremes. Based on the current costs applied by energy suppliers, the unit cost of power capacity is assumed to be 50 and 40 EUR/kW/year in the maximum and minimum cost scenarios, respectively.

The maintenance cost is estimated as a percentage, being the building maintenance cost of 0.25% for both cost scenarios; mechanical equipment with 5% (maximum scenario) and 4% (minimum scenario); and electrical equipment with 4% (maximum scenario) and 3% (minimum scenario). This assumption on maintenance costs gives a total (in percentage of total investment) of 2.4% and 1.9% in the maximum and minimum cost scenarios, respectively.

Fixed component also assumes a 19% of indirect costs (as reported in average by the WWTP operators). This assumption is also applied in the variable component.

Variable-cost component

This type of costs depend on the operating hours of the WWTP tertiary treatment and will be expressed in EUR/m^3. For the sake of simplicity, these costs will be estimated on an annual basis with the 100% of plant capacity in use.

Regarding labor costs, and based on the information gathered from our sample of WWTPs, we assume a total of 2,000 working hours of operational personnel per year in the maximum cost scenario and 900 working hours per year in the minimum cost scenario. It is worth noting that only marginal costs are considered, since the tertiary treatment is working in full-operating WWTPs with personnel also working in previous treatment phases (primary and secondary). In the case of the smallest scale (1 hm^3), working hours of operational personnel are assumed to be between 800 and 1,000 hours per year. Additionally to the operational personnel, technical personnel managing operational workers is also considered as a percentage (10%) of the working hours of operational personnel.

Regarding the filtering equipment, the change of 70 filter cloths per year are considered for the 10 hm^3 tertiary treatment plant, at a unit cost of 750 EUR. For the rest of plant sizes, the number of filter cloths are estimated proportionally. Similarly, 90 ultraviolet lamps are considered for the 10 hm3 plant, being proportionally calculated for the smaller plant scales.

Chemical analysis and water sampling is assumed to amount between 9,000 (minimum cost) and 18,000 EUR (maximum cost) per year for the 10 hm^3 plant, and between 6,000 (minimum cost) and 9,000 EUR (maximum cost) per year for the 1 hm^3 plant. The rest of plant sizes are lineally calculated. Chemical input, such as sodium hypochlorite, is assumed to be constant at a proportion of 0.06 Kg/m^3 at a cost of 0.30 EUR/kg.

Regarding electricity consumption, and based on the technical information gathered from our sample of WWTPs, it varies from 0.112 kWh/m^3 (10 hm^3) to 0.200 kWh/m^3 (1 hm^3). Electricity prices have being very unstable in the last months. With the aim to take into account this variability, a price of 0.12 EUR/kWh has been considered in the minimum cost scenario and a price of 0.15 EUR/kWh in the maximum cost scenario.

Finally, return wastewater flows and technical stops for filter cleaning are considered as a percentage of 8% on the variable energy cost.

Tables 2 and 3 summarize the cost calculation for three plant scales, being 1, 5 and 10 hm^3. Figures 4 and 5 shows the evolution of costs (total, fixed and variable) for the full range of plant scales, from 1 to 10 hm^3. As it can be observed, total costs vary between 0.07 (1 hm^3) and 0.13 (10 hm^3) EUR/m^3 in the minimum cost scenario, while costs are lightly higher in the maximum cost scenario, from 0.08 (10 hm^3) up to 1.15 EUR/m^3 (1 hm^3). It is also worth noting that fixed costs represent between 14% (10 hm^3) and 17% (1 hm^3) of total costs, depending on the plant scale.

Table 2. Tertiary treatment costs in the minimum cost scenario.

			Treatment capacity (hm^3)		
	Unit	*EUR/unit*	**1**	**5**	**10**
Investment unit cost (EUR/m^3)			0.60	0.43	0.36
Total investment (EUR)			601,100	2,168,592	3,616,312
Fixed costs					
Energy (power)	*kW*	*40*	50.0	87.8	135.0
Maintenance	*1.9%*		11,421	41,203	68,710
Fixed cost subtotal (EUR)			13,421	44,714	74,110
Indirect costs (EUR/m^3)	*19%*		2,550	8,496	14,081
Fixed Cost Total (EUR)			15,971	53,210	88,191
Fixed Cost Total (EUR/m^3)			**0.0160**	**0.0106**	**0.0088**
Variable costs					
Operational personnel	*Hours/year*	*35*	800	844	900
Technical personnel (10%)	*Hours/year*	*54*	80	84	90
Filter clothes	*unit*	*750*	7	35	70
UV lamps	*uni*	*830*	9	45	90
Sampling and analyses	*EUR/year*		6,000	6,044	18,000
Variable cost subtotal (EUR)			51,040	103,760	181,560
Variable cost subtotal (EUR/m^3)			0.0510	0.0208	0.0182
Sodium hyphoclorite	*Kg/m3*	*0.30*	0.0600	0.0600	0.0600
Electricity consumption	*KWh/m3*	*0.12*	0.2000	0.1609	0.1120
Return flows and stops	*8%*		0.0019	0.0022	0.0011
Variable cost subtotal (EUR/m^3)			0.0950	0.0603	0.0507
Indirect costs (EUR/m^3)	19%		0.0180	0.0114	0.0096
Variable Cost Total (EUR/m^3)			**0.1130**	**0.0717**	**0.0603**
Total Cost (EUR/m^3)			**0.129**	**0.082**	**0.069**

Following Figure 4 shows the cost evolution of fixed and variable cost components, as well as the total cost, for the full range of treatment scales.

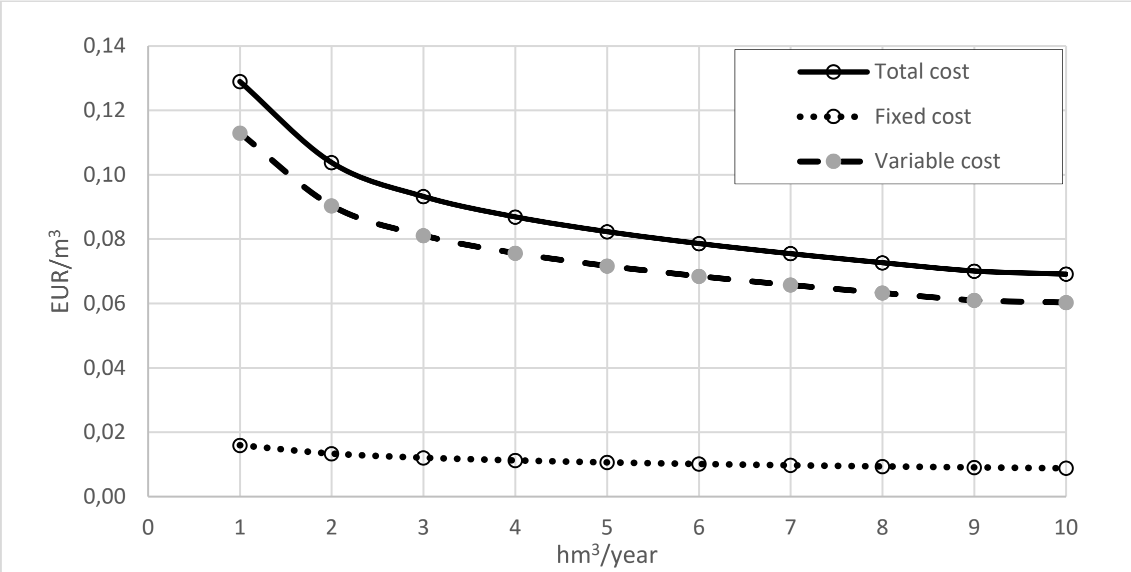

Figure 4. Cost – treatment capacity in the minimum cost scenario.

Table 3. Tertiary treatment costs in the maximum cost scenario**.**

			Treatment Capacity (hm^3)		
	Unit	*EUR/unit*	**1**	**5**	**10**
Investment unit cost (EUR/m^3)					
Total investment (EUR)			601,100	2,168,592	3,616,312
Fixed costs					
Energy (power)	*kW*	*50*	50.0	87.8	135.0
Maintenance	*2,4%*		14,426	52,046	86,791
Fixed cost subtotal (EUR)			16,926	56,435	93,541
Indirect costs (EUR/m^3)	*19%*		3,216	10,723	17,773
Fixed Cost Total (EUR)			20,142	67,158	111.314
Fixed Cost Total (EUR/m^3)			**0.0201**	**0.0134**	**0.0111**
Variable costs					
Operational personnel	*Hours/year*	*35*	1,000	1,444	2,000
Technical personnel (10%)	*Hours/year*	*54*	100	144	200
Filter clothes	*unit*	*750*	7	35	70
UV lamps	*uni*	*830*	9	45	90
Sampling and analyses	*EUR/year*		9,000	9,444	18,000
Variable cost subtotal (EUR)			62,120	131,400	226,000
Variable cost subtotal (EUR/m^3)			0.0621	0.0263	0.0226
Sodium hyphoclorite	*Kg/m^3*	*0.30*	0.0600	0.0600	0.0600
Electricity consumption	*KWh/m^3*	*0.15*	0.2000	0.1609	0.1120
Return flows and stops	*8%*	*EUR/m^3*	0.0024	0.0022	0.0011
Variable cost subtotal (EUR/m^3)			0.1125	0.0706	0.0585
Indirect costs (EUR/m^3)	19%		0.0214	0.0134	0.0111
Variable Cost Total (EUR/m^3)			**0.1339**	**0.0840**	**0.0696**
Total Cost (EUR/m3)			**0.154**	**0.097**	**0.081**

Figure 5 shows the cost evolution in the maximum cost scenario.

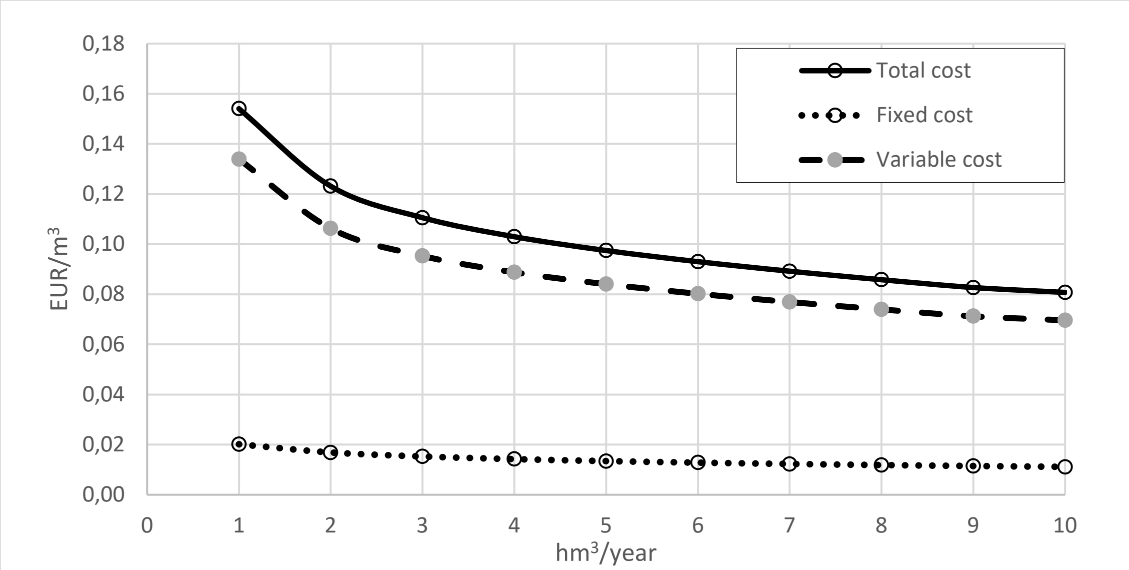

Figure 5. Cost – treatment capacity in the maximum cost scenario.

Costs increase significantly as the size of the plant is reduced as a result of the economies of scale. These economies of scale are easily observable in the graphical representation of costs by plant size (Figures 4 and 5).

4. Discussion and conclusions

Estimated costs offer valuable information to design a price scheme with a fixed and variable components, depending on the irrigation needs and treatment capacity of the WWTP. However, we believe that the price scheme should consider to establish a transfer price for those periods in which users do not demand water, and which should reflect strictly fixed costs.

Ability of the end user to pay will depend directly on the economic productivity of the water based on the profitability of the crops. Nevertheless, the analysis of payment affordability of irrigators requires to have a look to the cost of alternative water sources. The average irrigation price in Spain when only surface water is used amounts to 107 EUR/ha (0.02 EUR/m^3) and groundwater is around 50 EUR/ha (0.09 EUR/m^3). Alternatively, water production costs for large seawater desalination plants are currently around 0.4-0.6 EUR/m^3, with values that increase up to 0.8-1.2 EUR/m^3 if investment amortization is included (Zarzo, 2020). According to data from the Spanish Association for Desalination and Reuse (AEDyR, 2020), the current average seawater desalination prices in Spain are between 0.6 and 1 EUR/m^3. In brackish water, costs are much lower due to lower energy consumption, with highly variable values depending on salinity, and around 0.15-0.3 EUR/m^3. The only difference in costs between a brackish and sea water plant is due to energy consumption, the rest of the costs are usually very similar. These costs make reclaimed water a very competitive source compared to desalinated water.

In summary, conventional water sources are generally cheaper, while desalinated water cannot compete with reclaimed water. The problem arises when there is 'no' alternative water source available due to full exploitation, and often over-exploitation of the available resources. This overexploitation does not usually arise in superficial resources because they are easier to control and the allocation is based on resources guaranteed through multi-year models. On the contrary, underground resources are more uncertain and their control is more complex leading to late responses from the administration when the aquifer is being already overexploited. In any case, when the administration declares a system 'closed', due to the impossibility of meeting demands with conventional resources, reclaimed water enters the system. Therefore, when the cheapest sources run out, and there are no alternatives to increase supply (e.g., new reservoirs), reclaimed water is used, for example, to replace overexploitation of aquifers. Normally there are two purposes for the use of reclaimed water: supply augmentation or substitution of conventional sources (water saving).

Having said this, we can assume that a representative cost of the tertiary service, as we have seen in the previous section, would be around 0.10 EUR/m^3, to which transport and storage must be added. This last cost is much more variable, though some studies have given a conservative reference at around 0.15 EUR/m^3 (within the variability of this parameter) (Pistocchi et al., 2017). Consequently, in order to assume the costs of water regeneration by irrigation users, it would be necessary to cultivate crops whose marginal value of water exceeds 25 cents/m^3. It is again worth to note that this estimated cost does not take into account the amortization of the investment in tertiary equipment, which is often fully financed by the regional government, as it is the case in our case study.

Focusing on the payment affordability of irrigators in the DCMA, most irrigated lands are dedicated to horticultural crops (mostly being green-house farming), as well as fruit (e.g., citrus) and subtropical crops (e.g., avocado, mango), with a recent significant growth of irrigated olive groves. The payment capacity of these crops is usually very high and estimated around 0.50 EUR/m^3 for irrigated olive groves, 0.60 EUR/m^3 for avocado and mangos, and 1.50 EUR/m^3 in the case of horticultural crops (e.g., tomatoes, cucumbers, lettuces, etc.), based on the information gathered from the DCMA hydrological plan and the crop data from the Spanish Ministry of Agriculture (Expósito and Berbel, 2017; Martínez-Dalmau et al., 2023).

As main conclusion of this study, once the treatment costs have been comprehensively analyzed and the payment affordability of irrigators in the DCMA seems to be sufficient as shown by the economic water productivity of the cultivated crops, we believe that all efforts to put in value this non-conventional resource should be done by the public administrations and WWTP operators. Specially, in a current context where irrigators (but also the rest of economic sectors and general population) are suffering water cuts due to increasing water scarcity and a persistent drought period affecting southern Spain. Furthermore, other non-conventional water sources, such as desalination, imply greater production costs and have higher environmental impacts, making the use of reclaimed water a more sustainable alternative.

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