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Research article

Disentangling social perspectives on the use of reclaimed water in agriculture using Q methodology

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ABSTRACT

Reclaimed water is a promising alternative for irrigation in many water-stressed regions, but its expansion hinges on social acceptance. Previous studies have focused on the perceptions of consumers and farmers, overlooking the broader diversity of perspectives within the sector. This study seeks to address this gap by exploring the range of social perspectives on the use of reclaimed water for irrigation in Spain. Using Q methodology, we identified existing perspectives as well as synergies and frictions among them. We interviewed 23 stakeholders from environmental NGOs, food retailers, consumer and farmer organisations, public administrations, water treatment companies and associations, and water reuse experts. The results reveal three distinct perspectives: 1) reclaimed water must be promoted to secure agricultural production; 2) it has great potential, but needs technological improvement; and 3) it poses environmental risks, warranting cautious expansion. All perspectives agree that reclaimed water is a valuable resource for irrigation, but consumers lack sufficient information about its quality and benefits. Disagreements exist regarding its potential ecological impacts and who should bear the costs of reuse projects. Results suggest that avoiding negative environmental and socioeconomic impacts requires case by case consideration of reclamation technology and site-specific conditions. Additionally, awareness campaigns and stronger administrative support are crucial for promoting agricultural reclamation initiatives. This study underscores the importance of fostering stakeholder dialogue to promote sustainable and equitable reclaimed water use, ultimately supporting fair and effective water policies in Spain and other regions facing similar challenges.

1. Introduction

The reuse of reclaimed water from treated urban wastewater has long been utilised as a supplement to available water resources in agricultural irrigation (Mancuso et al., 2020). Its importance has increased in recent years due to global water scarcity, leading to the development of sustainable water management strategies that include and prioritise the use of reclaimed water (Shemer et al., 2023). This trend is particularly evident in ongoing policy discussions addressing the escalating frequency and severity of droughts in Mediterranean countries such as Spain (Caparrós-Martínez et al., 2020; Santos et al., 2023).

The advantages of reusing reclaimed water have been extensively discussed in the literature. Proponents argue that it can allow the recovery of nutrients, energy, biomolecules, and organic and inorganic compounds, thereby contributing to a circular economy and potentially reducing the volume of pollutants discharged into water bodies (Guerra-Rodríguez et al., 2020; Ofori et al., 2021; Romeiko, 2019). Critics have argued that it can pose health risks due to the potential presence of pathogenic microorganisms (Fernandes et al., 2023), as well as ecological challenges related to the contamination of soils (e.g. with salts, or heavy metals) and the potential reduction in water returns to water bodies (Valerio et al., 2021). Additionally, reclaimed water tends to be more costly due to the stringent treatment processes required to meet higher quality standards (Ricart and Rico, 2019; Hristov et al., 2021).

Another existing challenge is the widespread negative social perception of reclaimed water. This is fuelled by concerns regarding its suitability for irrigation and the 'yuck' factor - consumer disgust -

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reflecting a prevalent aversion rooted in cultural beliefs about water purity (Ricart et al., 2019; López-Serrano et al., 2022; Verhoest et al., 2022). However, studies also highlight that reclaimed water is recognised as a cost-effective, reliable, and safe alternative to traditional water sources like rivers, lakes and aquifers (Chen et al., 2013). It is perceived as a strategic resource that ensures maintenance of food production and alleviates water stress, particularly in arid and semi-arid Mediterranean regions (Alzahrani et al., 2023; Kalavrouziotis et al., 2015; Michetti et al., 2019; Sanchis-Ibor et al., 2020; Savchenko et al., 2019; Silva et al., 2023).

In Europe, reclaimed water reuse is a priority area in the Strategic Implementation Plan of the European Innovation Partnership on Water (EIPW, 2012). At present, 1000 hm^3 of treated urban wastewater is reused annually, with the potential for reuse estimated to be six times higher than the current use level (European Commission, 2023). Spain is the EU country with the highest potential and volume of annual reuse. It reuses 560 hm^3/year (nearly 10 % of the treated wastewater, well above the EU average of 2.4 %) with 73 % of this volume being used for agricultural irrigation (Eurostat, 2018).

Water reuse in Spain dates to the 1970s, but its use did not become widespread until the 2000s. The severe drought of 2005–2008 precipitated a strengthening of the regulation and increase in the use of reclaimed water through Royal Decree 1620/2007, which established the legal regime for the reuse of treated wastewater. Reclaimed water use increased rapidly from 198 hm^3/year to 500 hm^3/year between the 2000 and 2010. Since then, it has remained steady at 550 hm^3/year (Gómez-Ramos et al., 2024).

To promote increased adoption of reclaimed water in Spain, numerous strategies have been recently implemented within the circular economy framework (López-Ruiz and González-Gómez, 2023). These include the National Plan for Purification, Sanitation, Efficiency, Saving and Reuse (DSEAR Plan. Plan Nacional de Depuración, 2021), alongside the ongoing revision and adaptation of the Royal Decree 1620/2007 to align with EU Regulation 2020/741 on minimum quality requirements for water reuse for agricultural irrigation (Morote et al., 2019). These strategies collectively aim to support the Spanish government's objective of achieving 1000 hm^3/year of water reuse by 2027 indicated in Royal Decree-Law 4/2023 (Spanish Official Gazette, 2023).

Despite the growing momentum for the reuse of reclaimed water, there exists a notable gap in understanding the views of different stakeholders regarding its adoption and potential. Some studies have analysed stakeholder perceptions, often prioritizing aggregated insights over the nuanced perspectives of individual stakeholders. For instance, Ballesteros-Olza et al. (2022) used a stakeholder-based fuzzy cognitive map (FCM) to present a consensus view of the current state of reclaimed water reuse. Whereas Mesa-Pérez et al. (2020) employed a SWOT analysis to identify the perceived the strengths, weaknesses, opportunities, and threats associated with its use. In contrast, other studies, such as those by Ricart et al. (2019, 2022) have focused on specific stakeholder groups like farmers and consumers, addressing concerns such as environmental and health risks. Similarly, Zabala et al. (2019), and Moya-Fernández et al. (2021) conducted surveys to explore consumer perspectives, assessing perceived impacts, willingness to pay, and acceptance of reclaimed water for consumption. While these studies offer valuable insights, they often fail to fully capture the broader diversity of views within the sector.

To address this gap, this study aims to better understand the diversity of social perspectives that contextualise the use of reclaimed water in agriculture. Gaining a comprehensive understanding of these perspectives is crucial for identifying synergies and mitigating potential conflicts, thereby informing more effective policy decision-making. To this end, this study applies Q methodology, a tool designed to identify subjective viewpoints and construct shared narratives on complex topics. Originally developed in the field of psychology, Q methodology has gained widespread recognition in the environmental social sciences due to their suitability to understand perspectives on multifaceted and often polarising issues (Watts and Stenner, 2012; A. Zabala et al., 2018). The study focuses on Spain as it is a paradigmatic case in the use and promotion of reclaimed water. Results from this study can therefore provide useful insights into the use and deployment of this alternative water source in other arid and semi-arid regions of the world.

The article is divided into five sections. Section 1 introduces the relevance of reclaimed water in agriculture, highlights its benefits and challenges, and sets the research objectives. Section 2 describes the application of the Q methodology to analyse social perspectives on reclaimed water use. Section 3 presents the findings of the study, outlining the discourses identified and their key differences and areas of consensus. Section 4 contextualises the findings within the existing literature and explores policy and environmental implications. Finally, Section 5 summarises the study's contributions, limitations, and recommendations for future research.

2. Materials and methods

Q methodology was developed by Stephenson (1980) as a means of capturing different perspectives on an issue. It is a bridge between two methodological approaches, qualitative and quantitative, allowing the researcher to deal with the subjectivity and opinions of respondents in a systematic and in-depth way (Hampson et al., 2022). It is considered qualitative due to its focus on subjective data derived from individual values and its ability to produce meaningful insights without relying on large population samples, distinguishing it from traditional survey techniques. In addition, it incorporates quantitative elements, as data collection and analysis involve the use of statistical and mathematical techniques (Frantzi et al., 2009). This combination allows the methodology to reveal a set of social perspectives that explain participants' perceptions and the arguments underlying them, providing a robust and comprehensive framework for exploring complex social issues.

The first step of the Q methodology consists of defining and developing the Q-set, which is a population's set of opinions, ideas, and perceptions about an argument related to the research objective (Gholamrezai et al., 2023). In this research, we collected 101 statements on the perception of reclaimed water in Spain from scientific papers, press releases, reports, conference proceedings, and interviews with key stakeholders conducted as part of the RECLAMO project from March to July 2022 (Ballesteros-Olza et al., 2022). Each of the statements were analysed by the authors to ensure all aspects of reclaimed water reuse were covered: impact on the environment and crops, health risks, prices, economic costs, water quality, emotional reactions, awareness and information, regulations, management, governance, infrastructure, and technology. Duplicates were eliminated and the statements that conveyed the most concise and clear ideas about reclaimed water were selected. Finally, a total of 36 statements were chosen and tested in five pilot interviews, resulting in easily understandable statements.

The second step involves identifying the P-set, which comprises the study's participants. Although a large sample size is not required, the group must be diverse to capture a range of perspectives (Cooper and Wardropper, 2021). Participants are intentionally selected based on their relevance to the subject area (Novo et al., 2024). In this study, the P-set included 23 representatives from key stakeholder groups related to the use of reclaimed water in agriculture in Spain. These participants were carefully selected to reflect the entire reclaimed water use chain, drawing on a thorough literature review and the authors' prior work (Ballesteros-Olza et al., 2022). The group included representatives from environmental NGOs (4), food retailers (2), consumer organisations (1), farmer associations (3), public administrators (4), private water treatment companies (3), water treatment associations (2), and experts in water reuse (4).

The third step is the Q-sort, which consists of asking participants to rank statements according to their opinions. This step is performed on a forced distribution grid, known as a Q-grid. This grid employs a 5-point Likert scale, ranging from −5 (strongly disagree) to +5 (strongly agree)

(Finchilescu and Muthal, 2019). In the present research, the rankings were carried out using the Q method software (https://qmethodsoftware.com/), through virtual interviews conducted on ZOOM, due to the geographical dispersion of the participants, from March to July 2023.

During the interviews, a preliminary classification of the statements into three categories was conducted: those with which participants agreed, those they disagreed with, and those generating neutral or mixed opinions. Subsequently, the statements were sorted based on their relative level of agreement/disagreement using the Q-grid shown in Fig. 1. Columns on the left represent greater disagreement, and those on the right indicate greater agreement, while the boxes within each column have equivalent conformity values, whether positive or negative. The sorting process began with the category containing the most statements, either agreement or disagreement, and concluded with the neutral statements. Once the sorting was done, the participants were allowed to reclassify the statements if they were not satisfied with their initial sorting. Finally, respondents were asked about the classification of some statements and the reasons for this classification. Every participant provided written or verbal consent for the interviews to be recorded, transcribed, and used for analysis purposes. Throughout the study, their anonymity has been maintained.

The last step in Q methodology involves estimating factor scores for each statement and identifying the distinctive and common statements for each discourse. For this, a factor analysis was performed in R software using the 'qmethod' package (version 1.5.5) (Zabala, 2014). Principal Component Analysis (PCA) was used for factor extraction, which was subjected to a variamax rotation and a Spearman correlation coefficient.

3. Results

A 3-factor solution was selected, each of which shows a social perspective (discourse) on the use of reclaimed water in agricultural irrigation. This solution met the objective criteria for factor selection and generated coherent and meaningful qualitative discourses (Watts et al., 2012). Together, the 3-factors explained 61 % of the variance.

Each of the three discourses identified represents a unique social perspective on reclaimed water use and its implications in economic, social, and environmental terms. We labelled the discourses (factor) as: Discourse 1: Reclaimed water secures water supply for agriculture; Discourse 2: Reclaimed water has potential for improvement; and Discourse 3: Reclaimed water adversely affects the environment. All perspectives emphasised the importance of promoting reclaimed water to address climate change and droughts, and the differences across them lie mainly in perceptions of technologies, the costs/risks involved, and the potential for undesirable environmental impacts.

Table 1 shows the discourses obtained from the factor analysis. Each row displays the z-scores and the idealised Q sorts (IQS) for each factor in relation to the statements. The z-scores represent the weighted average of the Q sort values, which indicates the relationship between the statements and the factors, i.e., how much each factor matches a statement. These z-scores are also used to construct the idealised Q sorts for each factor (Pagot and Gatto, 2024). The IQS scores represent the positions in the Q grid that discourses would assign to each statement. The last column highlights both the consensus statements for all factors and distinguishing statements, identified based on the degree of statistical distinction between the factors. In addition, Table 2 reports the factor loadings of different stakeholders, including those defining each factor, which are marked with an asterisk (*).

The following sections provide a description and interpretation of each discourse. The idealised scores of statements are given in parentheses. Distinguishing statements are marked with an asterisk next to the statement number.

3.1. *Discourse 1. Reclaimed water secures water supply for agriculture*

This discourse explains 22 % of the total variance and includes 12 participants belonging to different stakeholder groups, such as public administrators, food retailers, farmer associations, water treatment associations and experts in water reuse.

This discourse emphasises the importance of reclaimed water as a constant and reliable water source for agricultural irrigation. The use of reclaimed water is regarded as a critical resource to ensure irrigation supply (16: +4), especially in situations where conventional water resources are limited or unavailable. In such circumstances, the demand for reclaimed water rises, further enhancing society's appreciation of reclaimed water (1*: +5). This shift towards a more positive perception of reclaimed water is particularly notable among farmers, who are the largest users of this resource (2*: −4):

> "Water scarcity raises awareness in society, which improves the social perception of the use of reclaimed water in agriculture" (FR2).

This discourse agrees on the overall lack of awareness regarding the benefits of reclaimed water, linked to misconceptions and misinformation about its quality and safety (5: −5). This knowledge gap prevents many from recognizing its potential advantages. Therefore, public education and awareness campaigns could improve social acceptance and encourage the adoption of this resource:

> "The perception of reclaimed water is not negative as such; the problem is that there is a lack of knowledge" (PA3).

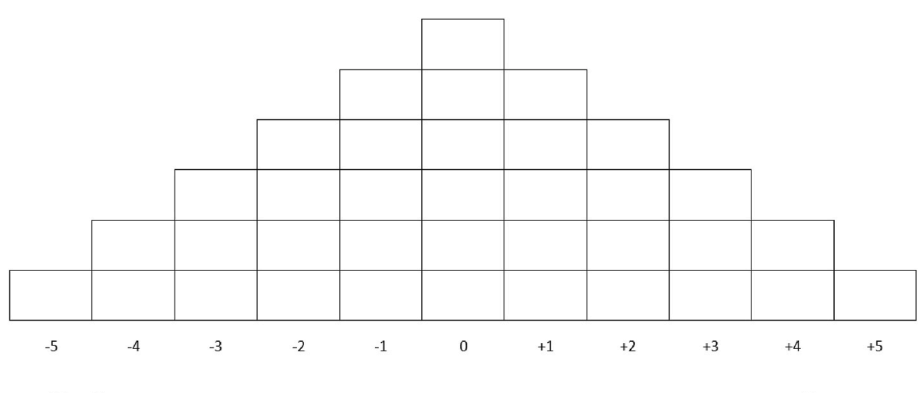

Fig. 1. The Q methodology grid used for this study.
Source: Own elaboration.

Table 1
Statements with z-scores (Z), idealised Q sort positions (IQS), and assessment of consensus and distinguishing statements.

Statement		Factor 1		Factor 2		Factor 3		Consensus/ distinguishing
Nº	Description	Z	IQS	Z	IQS	Z	IQS	
1	Growing water scarcity makes society favour greater use of reclaimed water	2.21	+5	1.27	+2	0.79	+2	Distinguishes Factor 1
2	Social perception of the use of reclaimed water in agriculture is negative	−1.58	−4	0.52	+2	0.11	0	Distinguishes Factor 1
3	Reclaimed water is socially perceived as a ‘waste’ and not as a ‘resource’ in the form of recovered water	−1.61	−4	0.35	+1	−0.14	0	Distinguishes Factor 1
4	The yuck factor is one of the main barriers to the adoption of reclaimed water in agriculture	−1.27	−3	1.61	+4	−0.54	−2	Distinguishes all factors: 1, 2, 3
5	Consumers are sufficiently informed about the quality of reclaimed water and its benefits	−1.67	−5	−1.98	−5	−1.41	−3	Consensus
6	Food retailers are reluctant to market products irrigated with reclaimed water	−1.17	−3	0.20	+1	−0.53	−1	Distinguishes all factors: 1, 2, 3
7	Public administrations are willing to promote the use of reclaimed water	1.40	+3	2.03	+4	1.53	+4	
8	Bureaucracy is a barrier to the establishment of new reclamation projects	1.29	+3	−0.09	0	−1.03	−2	Distinguishes all factors: 1, 2, 3
9	Irrigation with reclaimed water has quality requirements that are difficult to meet	−1.14	−3	−0.32	0	−1.54	−4	Distinguishes Factor 2
10	Very strict risk management plans for reclaimed water discourage its use	0.38	+1	0.21	+1	−0.63	−2	Distinguishes Factor 3
11	Strict quality standards for agricultural use improve confidence in the use of reclaimed water	1.59	+4	1.42	+3	1.28	+3	Consensus
12	Meeting the quality standards of the new EU Regulation means wasting resources (removing too many nutrients, which means higher costs)	−0.47	−1	−0.55	−1	−1.66	−4	Distinguishes Factor 3
13	Without public subsidies, water reclaim projects in agricultures cannot be developed	0.79	+2	−1.57	−4	−0.25	−1	Distinguishes all factors: 1, 2, 3
14	Farmers using reclaimed water are worried about water quality and its effects on the crop and soil	0.92	+2	−0.40	−1	−0.38	−1	Distinguishes Factor 1
15	Farmers are trained in the use of reclaimed water	0.98	+3	−0.60	−1	0.65	+2	Distinguishes Factor 2
16	The use of reclaimed water is a guarantee of supply for irrigation	1.80	+4	1.49	+3	−0.64	−2	Distinguishes Factor 3
17	Reclaimed water can reduce fertilizer application in agriculture	0.34	+1	2.12	+5	−0.25	−1	Distinguishes all factors: 1, 2, 3
18	The presence of emerging pollutants in reclaimed water is a limiting factor in the long term	0.49	+1	−0.61	−2	1.40	+3	Distinguishes all factors: 1, 2, 3
19	Use of reclaimed water in agriculture improves river water quality	0.10	0	−0.54	−1	−1.79	−5	Distinguishes all factors: 1, 2, 3
20	The water resources mix is essential to counteract the negative effects of reclaimed water	0.70	+2	−0.94	−3	−0.12	0	Distinguishes all factors: 1, 2, 3
21	Use of reclaimed water in agriculture lead to better water purification	0.42	+1	0.72	+2	0.90	+2	Consensus
22	Irrigation with reclaimed water causes risk of salinization soil	0.29	0	−0.85	−2	0.00	0	Distinguishes Factor 2
23	Irrigation with reclaimed water leads to soil pollution with heavy metals	−0.73	−2	−1.02	−3	0.38	+1	Distinguishes Factor 3
24	Irrigation with reclaimed water reduces discharges of nutrients and pollutants to sensitive marine environments	−0.16	0	0.66	+2	0.28	+1	
25	Irrigation with reclaimed water is a more environmentally friendly alternative water source to conventional water resources	0.69	+2	1.44	+3	−1.26	−3	Distinguishes all factors: 1, 2, 3
26	Irrigation with reclaimed water endangers compliance with ecological flows by reducing returns to rivers	−0.72	−2	−0.32	0	2.43	+5	Distinguishes Factor 3
27	The use of reclaimed water is an obligation for all basins, both deficit and surplus	0.09	0	−0.91	−2	−1.27	−3	Distinguishes Factor 1
28	Reclaimed water is water that is easy for farmers to access and manage	−0.80	−2	−0.35	0	0.13	+1	Distinguishes Factor 1
29	The use of reclaimed water in agriculture is costly compared to conventional water resources	−0.20	0	0.01	0	0.51	+2	
30	Farmers must pay for the full cost of reclaimed water	−0.42	−1	−0.95	−3	1.53	+4	Distinguishes all factors: 1, 2, 3
31	Irrigating with reclaimed water is affordable for farmers	−0.40	−1	0.19	+1	−0.12	0	
32	Water reclamation projects need to be large to be profitable	−0.30	0	−0.25	0	0.50	+1	Distinguishes Factor 3
33	Current reclamation technology has a high degree of maturity, with little possibility for improvement	−1.04	−2	−1.09	−4	−0.13	0	Distinguishes Factor 3
34	The low value of agricultural products in certain areas prevents the use of reclaimed water	−0.52	−1	−0.66	−2	0.38	+1	Distinguishes Factor 3
35	Use of reclaimed water helps ensure stable food prices	0.41	+1	0.14	+1	−0.38	−1	
36	The amount of reclaimed water that can be used is overestimated	−0.69	−1	−0.38	−1	1.28	+3	Distinguishes Factor 3

Source: Own elaboration

> “With more information, consumers would likely support reclaimed water use, as it aligns with their growing preference for sustainable products” (FR1).

This discourse also highlights that meeting the strict quality requirements of reclaimed water for agricultural use is achievable with existing technology. Furthermore, adhering to these standards seen as key to building public trust in this resource (11: +4).

> “Reclaimed water must meet strict quality standards to protect health the environment, which positively influences its social perception” (FA2).

Rigorous treatment processes effectively transform wastewater into a safe and valuable resource making it inappropriate to classify or label it as “waste” (3*: −4). Similarly, food retailers express confidence in marketing products from crops irrigated with reclaimed water (6*: −3). Therefore, the negative opinions often associated with reclaimed water (harmful, dangerous, disgusting) are considered unsubstantiated and are not seen as an obstacle to its use (4*: −3).

This discourse underscores that government support is crucial for implementing water reclamation projects, and that public subsidies are necessary for their development (13*: +2):

> “Due to high initial costs, reclamation projects need public support and increased investment from public administrations.” (PA3).

Overall, public administrations are seen as supportive of reclaimed water reuse initiatives (7: +3). However, excessive red tape remains a significant barrier to widespread adoption (8*: +3). Complex permitting and authorisation procedures can make it difficult for farmers to access and manage reclaimed water (28*: −2):

Table 2
Factor loadings obtained by extraction and rotation of significant factors.

Respondent ID	Stakeholder group	Factor 1	Factor 2	Factor 3
CO	Consumer organisation	−0.3115	0.114	0.7673*
EXP1	Water reuse expert	0.1084	0.467*	−0.1381
EXP2	Water reuse expert	0.5720*	0.383	0.2370
EXP3	Water reuse expert	0.7851*	0.039	−0.0467
EXP4	Water reuse expert	0.5590*	0.368	−0.1421
FA1	Farmer association	0.0091	0.636*	−0.2785
FA2	Farmer association	0.7346*	0.418	0.0449
FA3	Farmer association	0.5617*	−0.089	−0.0628
FR1	Food retailer	0.7010*	0.177	−0.0096
FR2	Food retailer	0.8057*	−0.185	0.1848
NGO1	Environmental NGO	−0.0843	−0.234	0.7715*
NGO2	Environmental NGO	0.1678	0.216	0.7755*
NGO3	Environmental NGO	0.3618	−0.034	0.7769*
NGO4	Environmental NGO	−0.0337	0.656*	0.4320
PA1	Public administration	0.5884*	0.450	0.0788
PA2	Public administration	0.1333	0.593*	0.2057
PA3	Public administration	0.6975*	0.257	0.0755
PA4	Public administration	0.0630	0.646*	0.0293
TC1	Private water treatment company	0.3302*	0.302	0.0070
TC2	Private water treatment company	0.6033*	0.031	0.4317
TC3	Private water treatment company	0.1830	0.463*	0.0381
WTA1	Water treatment association	0.1241	0.718*	0.0521
WTA2	Water treatment association	0.5192*	0.338	−0.1242

Source: own elaboration

> “The administration favours the use of reclaimed water, but it involves lengthy bureaucratic processes and delays.” (PA1).

This discourse also supports the “polluter pays” principle, suggesting that citizens (polluters) should bear the cost of treating wastewater to its original quality before discharge. Consequently, farmers should not cover the full cost (30*: −1):

> “As end-users of reclaimed water, farmers are only required to cover distribution costs, not reclamation expenses.” (FA3).

This discourse agrees that irrigation with reclaimed water has positive environmental effects (25*: +2). It reduces the demand for conventional freshwater, preserving this valuable resource for other essential users. In addition, by removing pollutants from wastewater, it lowers the risk of contaminating natural ecosystems.

However, it also recognizes that water reuse can diminish returns to rivers, potentially reducing their self-purification capacity. Therefore, while reclaimed water in agriculture may enhance water quality in some aspects, it may also pose certain challenges (19*: 0).

> “The quality of reclaimed water for irrigation can be better than that of rivers because it has to meet strict treatments standards.” (PA1).

> “Reclaimed water improves water quality of rivers, provided it does not affect the flow.” (EXP2).

Due to this concern, there is no consensus on whether the use of reclaimed water should be required in all basins, both deficit and surplus (27*: 0):

> “The use of reclaimed water in different river basins is considered an ethical principle, meaning it is recommended but not mandatory" (PA3)

Finally, ensuring the quality of reclaimed water is considered crucial for farmers to crop health and preserve soil (14*: +2). Emerging contaminants, whose long-term effects on the environment and human health are still unknown, can be a significant barrier (18*: +1). To mitigate potential negative effects, blending reclaimed water with conventional sources may be necessary (20*: +2):

> “In some areas of Spain, reclaimed water with high salt concentration, is mixed with conventional or desalinated water to reduce the salinity” (FA2).

3.2. *Discourse 2. Reclaimed water has potential for improvement*

This discourse explains 16 % of the total variance and encompasses 7 participants from various stakeholder groups, including water treatment associations, farmer associations, public administrators, and experts in water reuse, who typically possess a more technical orientation.

This discourse acknowledges the benefits of reclaimed water but suggests that there is still room for improvement in various aspects, particularly in enhancing treatment processes and public acceptance.

In line with discourse 1, irrigation with reclaimed water is considered an environmentally friendly alternative to traditional water sources (25*: +3). It not only alleviates pressure on freshwater resources but also improves soil health. Its nutrient-rich composition reduces the need for chemical fertilisers, thereby enhancing long-term soil fertility and sustainability (17*: +5).

Furthermore, unlike discourse 1, discourse 2 perceives reclaimed water as a safe and reliable resource with minimal risks of salinization (22*: −2) or the presence of emerging contaminants (18*: −2):

“The salinity of reclaimed water depends on its source, i.e. wastewater, and is generally not a significant concern” (WTA1).

> “Scientific evidence confirms the safety of reclaimed water, with no substantial proof of emerging contaminants or related risks” (PA4).

Therefore, mixing reclaimed water with conventional water sources is not considered necessary to mitigate potential negative effects (20*: −3):

> “Blending water can reduce salinity, but it is ineffective from a microbiological perspective. In fact, conventional water is of poorer quality than reclaimed water” (PA2).

However, this discourse tends to agree that the use of reclaimed water in agriculture can diminish the quality of rivers (19*: −1), as it reduces the flow of water with higher quality than would otherwise be discharged into the river.

In addition, this discourse suggests that reclaimed water is subject to a negative social perception (2*: +2) largely due to its origin as wastewater and the “yuck factor” (instinctive aversion or feeling of disgust towards treated wastewater) (4*: +4):

> “The yuck factor fuels society reluctance towards the use reclaimed water, but greater awareness of the urban water cycle may reduce this perception” (PA4).

Like the findings in discourse 1, consumers are unaware of the benefits and high quality of reclaimed water (5: −5). However, this discourse presents a contrasting perspective, suggesting that this lack of knowledge is among the reasons why food retailers are reluctant to market products irrigated with reclaimed water (6*: +1):

> “Food retailers worry that mismanagement of reclaimed water could alarm consumers and damage their brand image” (TC3).

In terms of reclamation technology, this discourse considers that it has reached a high level of maturity and that meeting irrigation quality standards is no longer a challenge (9*: 0). However, it recognizes that further improvements are possible to increase the efficiency of these technologies (33: −4). Ongoing technological advancements provide opportunities to make water treatment more reliable and cost-effective:

> “The technology has scope to reduce costs, improve membrane lifespan and nutrient management” (WTA3).

This discourse strongly agrees that cost reduction in water treatment processes would allow reclamation projects to be undertaken by farmers, without financial support (13*: −4):

> "Public subsidies are not necessary to develop reclamation projects, as there are existing projects fully funded by farmers" (NGO4).

However, farmer-funded projects often prioritise the irrigation of high-value crops because of their potential for higher economic returns. Reclamation projects require significant investment in infrastructure and pipelines to connect the wastewater treatment plant (WWTP) to the fields. Therefore, as in discourse 1, it is argued that farmers should not bear the full cost of reclaimed water production (30*: −3):

> "According to the polluter pays principle, water users (citizens) are responsible for treating the water they use. Farmers should only pay for water once it leaves the WWTP" (FA1).

Finally, this discourse agrees with discourse 1 that there is a willingness on the part of administrators to promote the use of reclaimed water in agriculture (7: +4). However, unlike discourse 1, bureaucracy is not seen as a barrier (8*: 0). Instead, it emphasises the necessity for farmers to receive better training in the use of reclaimed water (15*: −1):

> "Managing reclaimed water is challenging for farmers, requiring knowledge and precautions, particularly concerning storage. In addition, implementing the risk management plans required by the new Royal Decree is complex and demands support and guidance" (WTA1).

3.3. Discourse 3. Reclaimed water adversely affects the environment

This discourse explains 13 % of the total variance and includes 4 participants belonging to different stakeholder groups, such as consumer organisations and environmental NGOs.

The discourse stresses the importance of taking into account geographical aspects and potential environmental impacts when using reclaimed water for irrigation. It argues that reclaimed water should only be considered as a new resource in coastal areas. In inland basins, it often it often re-enters water bodies through surface runoff or groundwater infiltration, becoming part of the hydrological cycle. Overlooking this may lead to an overestimation of the actual volume of reclaimed water available for use (36*: +3). In addition, it warns that using reclaimed water for agriculture may endanger compliance with ecological flows (26*: +5):

> "There is confusion between direct and indirect reuse. Irrigation with reclaimed water (direct reuse) only makes sense in coastal areas" (NGO2).

> "To prevent damage to ecosystems, reclaimed water should only be used in substitution of conventional water resources (CO).

In contrast to discourse 1, this discourse disputes the notion that reclaimed water can offer a reliable supply for agricultural irrigation (16*: −2) and strongly supports the notion that its use in agriculture negatively impacts river quality (19*: −5).

> "Reclamation projects should be evaluated on a case-by-case basis to carefully assess their impact on river flows and the reduction of the rivers' self-purification capacity" (NGO1).

Unlike discourse 2, it highlights the long-term concerns posed by emerging pollutants (18*: +3) and soil pollution caused by heavy metals resulting from irrigation with reclaimed water (23*: +1). Furthermore, it is believed that blending water resources (reclaimed water and conventional water) can help mitigate the negative effects of reclaimed water, although it will not completely counteract them (20*: 0):

> "The existence of pollutants in treated wastewater may limit the reuse of reclaimed water" (NGO2).

Also, in contrast to discourse 2, this discourse suggests that irrigation with reclaimed water may not consistently reduce fertiliser consumption, and could even require additional fertilisation in some cases (17*: −1):

> "Reclaimed water contains nutrients beneficial to plants, but it does not provide all the essential nutrients for optimal growth. Additionally, it may contain contaminants that could inhibit plant nutrient uptake or negatively affect soil fertility." (NGO1).

As a result, this discourse agrees that the use of reclaimed water for irrigation is detrimental from an environmental point of view (25*: −3). Though technological advances in reclamation could help to alleviate these negative environmental effects, economic barriers hinder progress in this direction (33*: 0):

> "Increased economic investment is necessary to achieve enhancements in reclamation technology, particularly given the existence of emerging contaminants that lack treatment solutions." (NGO1).

In line with discourse 2, this discourse acknowledges that public subsidies are not the only option for developing water reclamation projects in agriculture (13*: −1):

> "There is significant private initiative for water reclamation projects, driven by the profitability of irrigation" (NGO2).

In contrast to the other two discourses (1 and 2), this discourse asserts that farmers should bear the entire cost of the reclamation process (30*: +4), because they directly benefit from it. It acknowledges that large reclamation projects are more profitable due to economies of scale (32*: +1), but highlights the difficulty of implementing such projects in regions where agricultural products have low value (34*: +1).

According to this discourse, the new European regulation imposes rigorous quality requirements and risk management plans which, though not without challenge, are not difficult to meet (9: −4) and therefore do not discourage the use of reclaimed water (10*: −2). Furthermore, this discourse opposes the idea that complying with the quality standards of the new EU regulation results in resource wastage by removing excessive nutrients (12*: −4):

> "The quality standards are not overly strict; on the contrary, they are necessary to ensure food safety." (CO).

Like in the other two discourses (1 and 2), this discourse reveals a strong consensus regarding administrator willingness to promote the use of reclaimed water (7: +4). Moreover, bureaucracy (8*: −2) and the "yuck factor" (4*: −2) are not perceived as impediments, indicating that reclaimed water is considered a valuable resource rather than waste (3*: 0). This suggests that there is no reluctance to promote food irrigated with reclaimed water (6*: −1):

> "Using reclaimed water in agriculture can boost a food brand's image by showcasing its commitment to sustainability and environmental responsibility" (NGO2)

In line with discourses 1 and 2, the primary issue is the lack of consumer information (5*: −3):

> "There is no reluctance to reclaimed water because there is no information However, with a well-executed campaign, this situation could be easily and effectively changed" (NGO3).

3.4. Consensus and disagreement

Findings from a Q study can be valuable for identifying specific areas of agreement and disagreement among different perspectives (Brannstrom et al., 2022). This understanding, often overlooked in Q studies, can be important for guiding discussions, focusing on the most significant issues and facilitating negotiations and compromises by overcoming seemingly irreconcilable positions (Huaranca et al., 2019;

Iribarnegaray et al., 2021).

Fig. 2 illustrates specific statements with the highest level of agreement between the factors (discourses). The central section highlights the statement with the greatest consensus among the three factors, indicated by the smallest differences in Z-scores. Notably, all discourses agree that consumers are not sufficiently informed about the quality and benefits of reclaimed water (statement 5; 1: −5, 2: −5, 3: −3).

Intermediate sections show statements with the highest agreement between pairs of factors (smaller differences in Z-scores identified by pairs of factors). Discourses 1 and 2 agree that current reclamation technology is not fully mature and can be improved (statement 33; 1: −2, 2: −4), while discourses 1 and 3 share the view in recognizing public administrations' eagerness to promote the use of reclaimed water (statement 7; 1: +3, 3: +4). Discourses 2 and 3 concur that rigorous quality control ensures reclaimed water meets high standards, alleviating farmers' concerns about its effects on crops and soil (statement 14; 2: −1; 3: −1).

Finally, the outer section contains the statements each discourse agrees with the most. For example, Fig. 2 shows a strong agreement regarding the idea that growing water scarcity makes society favour greater use of reclaimed water (statement 1, factor 1).

Fig. 3 illustrates the statements with the level of disagreement between the discourses, indicated by the largest differences in Z-scores.

As shown in the central section of Fig. 3, the main point of contention between all discourses is the idea that irrigation with reclaimed water endangers compliance with ecological flows by reducing returns to rivers (statement 26; 1: −2, 2: 0, 3: +5). This statement also shows the greatest disagreement between discourses pairs 1–3 and 2–3 (see intermediate sections in Fig. 3). In addition, between discourses 1 and 2 there is strong disagreement on the statement concerning the "yuck factor" as a barrier to the adoption of reclaimed water in agriculture (statement 4; 1: −3; 2: +4).

Lastly, the outer section contains the statements with which each discourse disagrees the most. Different statements related to social perception (statement 2; discourse 1), public subsidies to reclaimed water projects (statement 13; discourse 2) and water quality (statement 19; discourse 3) elicit strong disagreement.

4. Discussion

The results suggest that there is general agreement regarding the use of reclaimed water in agriculture to address water scarcity in Spain. However, there are differences between social perspectives with respect to who should bear the cost of the projects (consumers, farmers or administrators), the effects of these projects on river flows and the environment, and consumers' perceptions of this water source.

In line with Ricart et al. (2021), our findings indicate that the growing concern over climate change and water resource scarcity favours the development of water reclamation projects (discourse 1). However, these projects can be hindered by the high cost of reclaimed water as indicated in discourse 2 and raised by previous work on the topic (Berbel et al., 2024; Molinos-Senante et al., 2013; Santos et al.,

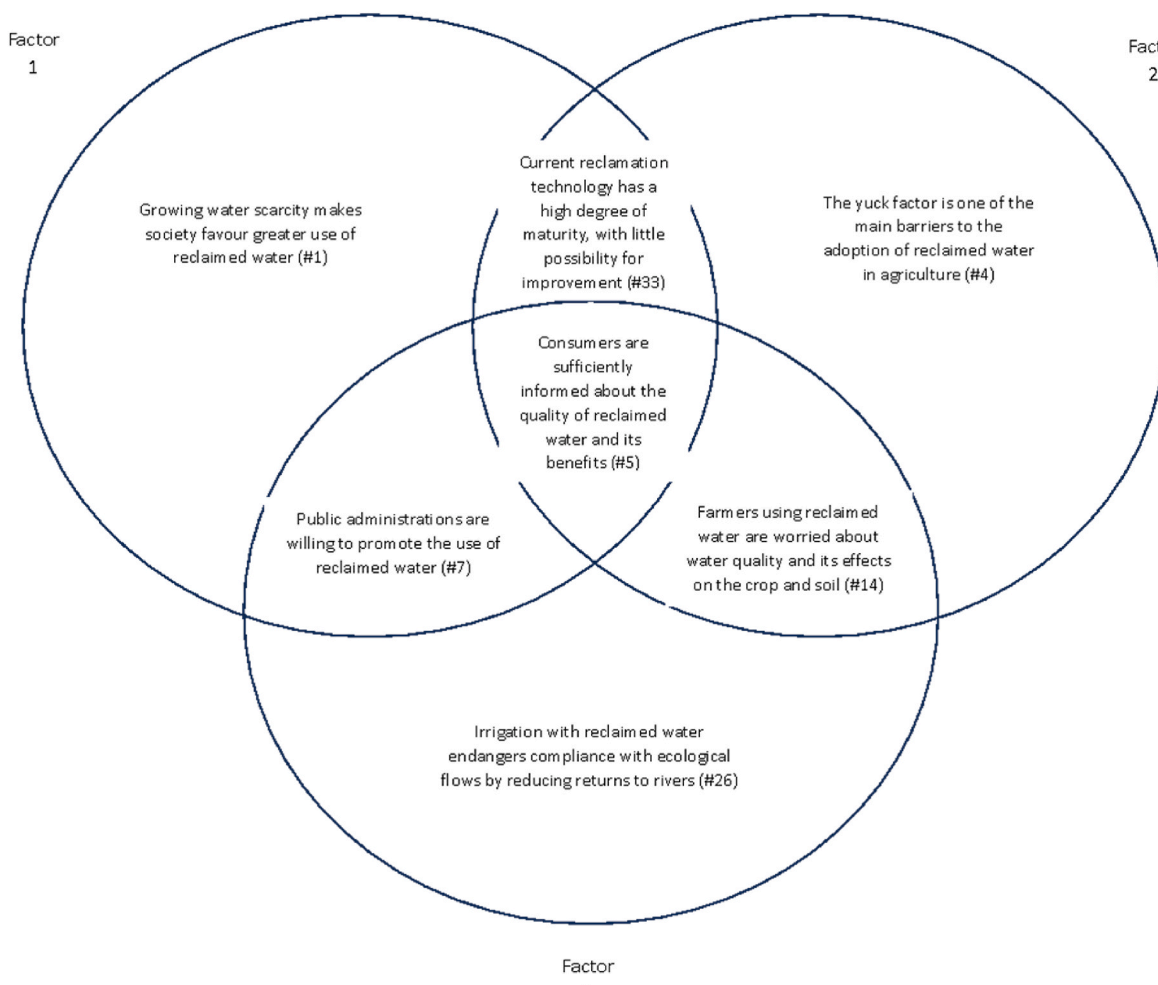

Fig. 2. Consensus. Statements with highest level of agreement between discourses 1, 2 and 3.
Source: Own elaboration

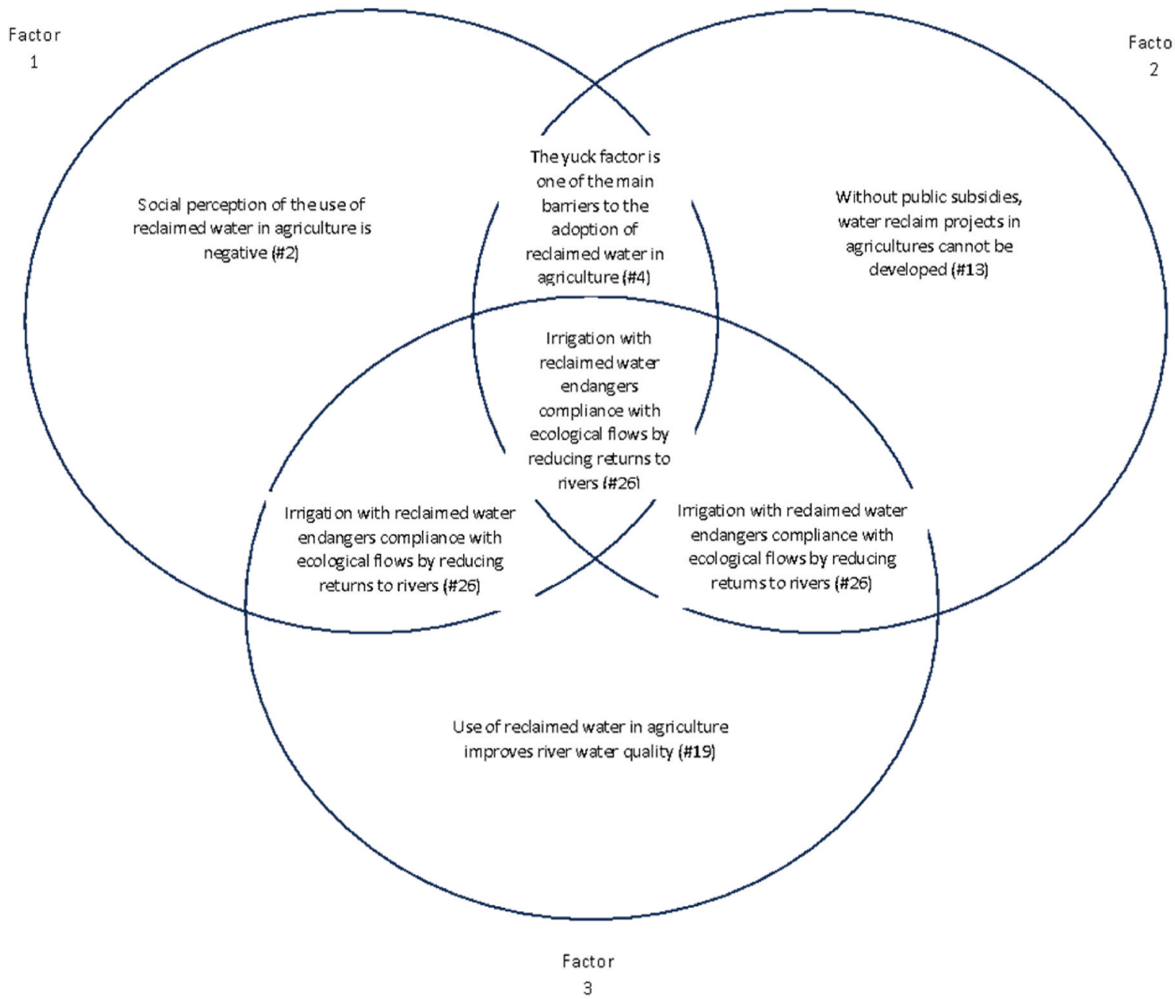

Fig. 3. Disagreement. Statements with the lowest level of agreement between discourses 1, 2 and 3.
Source: Own elaboration

2023). Generally, the cost of reclaimed water is higher than that of conventional water resources due to the technology required for its production (Mesa-Pérez et al., 2020; Expósito et al., 2024). In many regions of Spain, such as Valencia (Hagenvoort et al., 2019) and Murcia (Alcon et al., 2013), it is the citizens who bear the cost through a "treatment charge" ('canon de saneamiento') in their water bills, following the "polluter pays" principle. This is in line with the points mentioned in discourses 1 and 2. However, as indicated by discourse 3, and supported by Ricart et al. (2019), the actual cost of reclaimed water should be borne by the end user, in this case the farmer, rather than the polluter since under the terms of the WFD, reclaimed water can be considered a private asset with market value (Hernández-Sancho and Bellver-Domingo, 2022).

To address this situation, measures such as investment in the nationalisation of WWTPs to enhance their use, or public subsidies that reduce the cost for farmers, as suggested by López-Serrano et al. (2022), could be implemented. A solution that encompasses both measures is proposed by Jodar-Abellan et al. (2019), which involves distributing the costs of reclamation and wastewater management among citizens, farmers and the administration, establishing incentives to ensure that reclaimed water is used whenever possible.

Palacios-Diaz et al. (2015) suggests that subsidies can be used to cover part of the cost of reclaimed water. This aligns with the views presented in discourse 1. However, some respondents from discourses 2 and 3 have indicated that subsidies are not necessary, citing experiences of self-financed projects by farmers who can afford using reclaimed water because they irrigate high-value crops.

In addition, according to Discourse 3, the use of reclaimed water may negatively impact the environment both quantitatively (reduction of river flow) and qualitatively (altered water composition). Ballesteros-Olza et al. (2022) and Expósito et al. (2024) suggest that in inland areas, using reclaimed water reduces discharges from wastewater treatment plants to rivers, potentially endangering ecological flows and affecting biodiversity and water quality. The other two discourses (1 and 2) offer a more neutral perspective on the ecological impacts of reclaimed water use, noting that various river basin authorities are actively working to prevent the reduction of ecological flows through case-by-case studies. To avoid negative impacts, Gómez-Ramos et al. (2024) state that a river basin vision is needed as it is crucial to consider the whole water cycle to determine the available amount of reclaimed water for irrigation.

In terms of water quality, discourse 2 shares the view of Alcaide Zaragoza et al. (2020) that reclaimed water contains nutrients that can reduce the need for fertilisers in agriculture. However, it can also contain salts, heavy metals and emerging pollutants, depending on its origin (Xu et al., 2016), making it an environmentally unfriendly resource. This argument was raised by discourse 3 and supported by Wang et al. (2017). The other two discourses (1 and 2), however, view reclaimed water as a more environmentally friendly alternative to conventional water resources, consistent with Dolnicar & Schäfer (2009). Nonetheless, discourse 1 expresses concerns about the long-term effects of salts and emerging pollutants on soil and irrigation systems, echoing similar issues raised by Sunyer-Caldú et al. (2022). As noted by Jodar-Abellan et al. (2024), the cumulative effects on soil health, water quality, and irrigation infrastructure remain insufficiently understood, emphasizing the urgent need for further research to comprehensively assess these risks. To minimise environmental impacts, an integrated approach is essential, including the improvement of treatment technologies, effective management at both the catchment level and by farmers through sustainable soil and crop practices, and a robust regulatory framework ensuring compliance with quality standards and continuous monitoring (Ballesteros-Olza et al., 2022; Heinz et al., 2011; Santos et al., 2023).

Another significant barrier to the adoption of reclaimed water projects, as stated by Savchenko et al. (2019) and highlighted in discourse 1, is the high level of bureaucracy required to implement these projects. According to Berbel et al. (2023) and Ramm and Smol (2023) this bureaucracy leads to delays and increased costs, thereby hampering the use of reclaimed water in agriculture. However, there are efforts to overcome this challenge. Qtaishat et al. (2022) and McLennan et al. (2024) notes that the current transposition of the new EU regulation 2020/741, supported by the new Spanish Royal Decree 1085/2024, aims to address this issue by streamlining procedures and creating a more cohesive regulatory framework.

The social perception of reclaimed water use in agriculture is generally positive, but still needs improvement according to all discourses. As indicated in discourse 1, farmers express concerns about the effects of reclaimed water on the crops and soil. This aligns with Sheidaei et al. (2016) who argue that farmers have conflicting attitudes toward using wastewater for irrigation due to concerns about its negative impacts on health and the environment. In terms of consumer perception of reclaimed water, discourse 2 emphasises the “yuck factor” associated with its origin in wastewater (McClaran et al., 2020), leading to it being seen as waste rather than a valuable resource (Ellis et al., 2019). In contrast, Mendoza-Espinosa et al. (2019), in agreement with discourses 1 and 3, considers reclaimed water a valid resource for agricultural irrigation due to its high quality, meeting standards of the new EU regulation 2020/741, and therefore does not view the “yuck factor” as a significant obstacle to promoting reclaimed water. Nonetheless, according to Ricart et al. (2019), it is important to improve public perception through awareness campaigns, which would also allow consumers to better understand its use and benefits (Garin et al., 2021).

The findings of this study underscore the potential of reclaimed water as a promising option for semi-arid regions. However, they also emphasize the need to address critical aspects such as financing, ecological impacts, and social perception, while fostering stakeholder dialogue to align interests, encourage coordinated action, and achieve equitable and sustainable outcomes.

Finally, it is important to consider that the findings are shaped by the socioeconomic and physical context of the case studied, which may limit their direct applicability to other regions. Nevertheless, key themes, such as technological development, ecological impacts, cost allocation, and public awareness, remain relevant to many water-scarce countries seeking to integrate reclaimed water into their water management strategies. For instance, similar challenges and opportunities have been explored in the Mediterranean area (Michetti et al., 2019) the Middle East (Alzahrani et al., 2023), Australia (Radcliffe and Page, 2020), and California (Paul et al., 2020). These shared themes provide a foundation for broader applicability and emphasize areas where insights from this study may contribute to advancing reclaimed water initiatives globally.

5. Conclusion

The existing literature provides valuable insights into the use of reclaimed water in agriculture; however, it has not fully captured the diversity of perspectives within the sector. This study addresses this gap by applying Q methodology, a novel approach in this context, to explore the range of social perspectives that shape its use. The analysis identified three discourses: 1: “Reclaimed water secures water supply for agriculture”; 2: “Reclaimed water has potential for improvement”; and 3: “Reclaimed water adversely affects the environment”. Overall, all discourses agree on the need to promote water reuse with the support of both political administrations and wider society, especially in the face of increasing water scarcity.

There are, however, two important points of divergence between discourses regarding responsibility for costs, and environmental impacts. On cost allocation, discourses 1 and 2 support the “polluter pays” principle, while discourse 3 favours the WFD’s “end user pays” approach, which places the full financial burden on farmers. This latter model may hinder the development of reclamation projects, highlighting the need for supportive policies that ease financial pressures and encourage adoption.

Regarding environmental impacts, discourse 3 warns that using reclaimed water in inland areas could reduce return flows to rivers, potentially disrupting ecological balance. In contrast, discourses 1 and 2 maintain that river basin authorities effectively regulate water use to protect ecological flows. Addressing these concerns requires case-by-case environmental assessments and adaptive, site-specific strategies that balance agricultural needs with ecosystem protection.

Although general social perspectives are positive, resolving existing disagreements is essential for broader acceptance and successful implementation. Policymakers can help bridge stakeholder divides by providing targeted financial incentives, adopting flexible, region-specific environmental safeguards, and implementing public awareness campaigns. These strategies can inform proactive social and political approaches, supporting similar initiatives in other Mediterranean regions facing water scarcity.

While this study provides valuable insights into the social dynamics of reclaimed water use, several limitations must be acknowledged. A limitation inherent to Q methodology is its reliance on purposive sampling, which prioritises the diversity of viewpoints over statistical representativeness. Although key stakeholders were carefully selected, the findings do not allow generalizations as to what discourse is more prevalent within society. To address this, future research could integrate Q methodology with quantitative surveys to triangulate findings. Moreover, the concourse used in this study reflects the current state of knowledge and opinion, which is likely to evolve over time. Future studies could therefore examine how social perceptions change in response to factors such as regulatory shifts and technological advancements. Comparative analyses across international contexts could also provide valuable insights into how different legal, socio-cultural, and climatic conditions influence the acceptance and use of reclaimed water. Lastly, long-term environmental assessments will be critical for evaluating its sustainability and supporting wider implementation.

CRediT authorship contribution statement

Cintya Villacorta-Ranera: Writing – review & editing, Writing – original draft, Software, Resources, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **Irene Blanco-Gutiérrez:** Writing – review & editing, Writing – original draft, Visualization, Validation, Supervision, Resources, Project administration, Methodology, Investigation, Funding acquisition, Conceptualization. **Paula Novo:** Writing – review & editing, Writing – original draft, Validation, Supervision, Software, Resources, Methodology, Investigation, Formal analysis, Data curation, Conceptualization.

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.

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Data availability

Data will be made available on request.

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