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RESEARCH ARTICLE

Identified barriers and solutions for sustainable water in Europe: an analysis of seawater and wastewater mining

[version 1; peer review: 1 not approved]

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v1 **First published:** 04 Aug 2026, **6**:272
https://doi.org/10.12688/openreseurope.24474.1
Latest published: 04 Aug 2026, **6**:272
https://doi.org/10.12688/openreseurope.24474.1

Abstract

Background

This paper presents an analysis of six case studies and two replication studies across Europe exploring sustainable and circular water solutions, focusing on desalination and urban-industrial wastewater mining.

Methods

The findings are based on the results of co-creation workshops hosted for each case study, where experts from a range of relevant fields provided their vision of the barriers and potential solutions for each specific technology and location. The workshops were conducted according to a common methodology, enabling inter-comparability.

Results and Conclusions

The study concluded that industry and policymaking conservatism, lack of pilot and demonstration projects, insufficient public-private collaboration, bureaucratic inefficiencies, misconceptions and general lack of awareness about resulting products and processes, and policy challenges for the valorisation of recovered products constitute cross-cutting barriers across case studies.

Public awareness campaigns, policy reforms and institutional support were consistently considered key factors to trigger the upscaling of sustainable water circularity solutions in Europe.

Open Peer Review

Approval Status ✗

	1
version 1 04 Aug 2026	✗ view

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Any reports and responses or comments on the article can be found at the end of the article.

Keywords
Water circularity, desalination, sustainable water technology, policy, Europe, wastewater

This article is included in the Horizon 2020 gateway.

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Author roles: Picon C: Conceptualization, Data Curation, Formal Analysis, Investigation, Methodology, Visualization, Writing – Original Draft Preparation, Writing – Review & Editing; **van der Gaast W**: Funding Acquisition, Investigation, Methodology, Writing – Review & Editing

Competing interests: No competing interests were disclosed.

Grant information: This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No [869474] (WATERMINING).

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How to cite this article: Picon C and van der Gaast W. **Identified barriers and solutions for sustainable water in Europe: an analysis of seawater and wastewater mining [version 1; peer review: 1 not approved]** Open Research Europe 2026, **6**:272 https://doi.org/10.12688/openreseurope.24474.1

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Introduction

Water scarcity has become one of the most pressing environmental and socio-economic challenges facing Europe. Population growth, climate change, prolonged droughts, increasing agricultural demand, industrial development, and the deterioration of freshwater resources are placing growing pressure on conventional water supplies. Southern European regions are particularly vulnerable, where recurring water shortages increasingly threaten agricultural production, industrial activities, ecosystem health, and urban water security (Garrote et al., 2018). Transitioning towards more circular approaches to water management that minimize waste while recovering valuable resources is therefore crucial to ensure future environmental, social and economic sustainability.

Within this context, circular water technologies have emerged as solutions for the European transition towards a circular economy. Instead of treating wastewater or desalination brine as waste streams, these technologies recover water together with resources such as salts, minerals, biopolymers that can be reintroduced into industrial and agricultural value chains. The growing importance of these technologies is reflected in European policy initiatives including the European Green Deal (European Commission, 2019), the Circular Economy Action Plan (European Commission, 2020a) and the Water Reuse Regulation (European Commission, 2020b), all of which promote resource recovery and circularity in water management.

Despite technological progress, the widespread deployment of circular water solutions remains limited. Existing research has largely focused on technological performance, energy efficiency, environmental impacts and life-cycle assessment, while less attention has been dedicated to the institutional, regulatory, economic and market conditions that determine whether these technologies can successfully move beyond demonstration projects into large-scale implementation. Many promising technologies fail to reach commercial deployment due to fragmented legislation, limited market acceptance, unclear business models, insufficient institutional coordination or administrative barriers. Since these constraints are often highly context-specific, understanding them requires direct interaction with practitioners, policymakers, and industry representatives involved in technology implementation.

This paper addresses this gap by analysing barriers to the implementation of circular water technologies across six European demonstration case studies and two replication case studies developed within the EU-funded WATER-MINING project. The study covers seawater desalination, urban wastewater treatment and industrial wastewater treatment in Portugal, Spain, Italy, Cyprus, the Netherlands, Greece and Germany. A common participatory methodology based on market system analysis and co-creation workshops was applied across all case studies, enabling systematic comparison of barriers and proposed solutions despite differences in technologies and geographical contexts.

By synthesising the workshop results, this research identifies both cross-cutting and location-specific barriers affecting the deployment of circular water technologies. The findings provide policy-relevant recommendations for accelerating the transition towards circular water management in Europe.

Methods

This research is based on six case studies in Portugal, Spain, Italy, Cyprus, and the Netherlands, where circular water treatment technologies were deployed and assessed, and two replication case studies in Greece and Germany, which considered the conditions for technology deployment. All the cases involved co-creation workshops with industry experts to identify barriers and their solutions. Co-creation was conducted following ethical standards requiring explicit informed consent about the purpose of this activity according to EU and GDPR requirements, and all CoP assistants are matter experts familiar with collaborative processes. A combination of market mapping, root cause analysis, and workshop feedback formed the basis of this study. An overview of the process followed in this study can be seen in.

Preliminary policy and market research was conducted to develop an initial Market Map (as discussed in the Market Mapping section). During the first iteration of Participatory Analysis, this map was reviewed and discussed by project researchers along with a select group of industry experts. In the second iteration, the market map underwent further discussion and validation with a broader group of experts, representing diverse roles within the sector, known as a Community of Practice (CoP) (See Figure 1 for their composition). The third iteration of participatory analysis enabled the CoP to identify and validate market barriers. Once the researchers understood the market system and its obstacles, the conclusions were analysed and aggregated as overarching or specific. The main steps of this process are explained below.

Market mapping

This literature review examines current market systems, enhancing "market literacy." The Market System Analysis (MSA), based on Practical Action's framework (Hellin et al., 2005), has been previously applied in various contexts, such

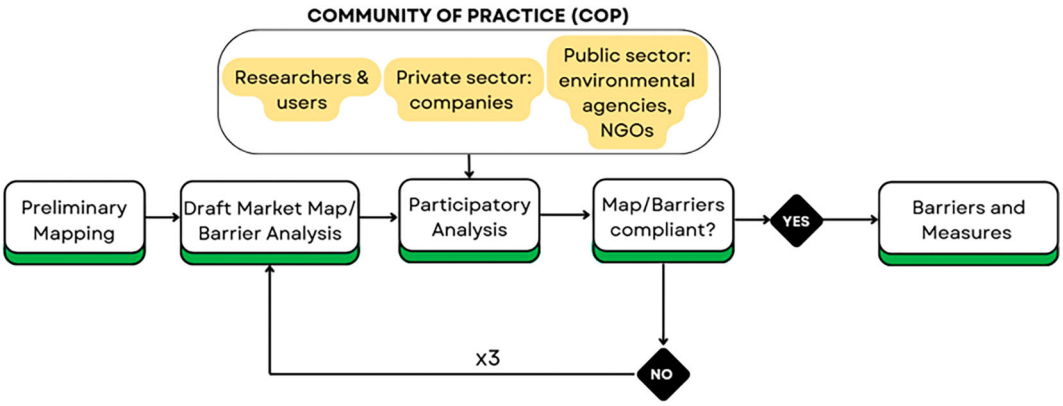


Figure 1. Overview of the methodology.



Figure 2. Technologies studied and their corresponding case study locations. Replication case studies are represented with a white background.

as the UNDP's Technology Needs Assessment Handbook (UNDP, 2010) and projects focusing on stakeholder engagement in technology deployment (Nikas et al., 2017; van der Gaast, 2017).

MSA involves mapping three primary elements: (1) market actors active in the value chain, identifying collaborators and competitors; (2) supporting services, including institutions that underpin market stability, such as financial, educational, and legal systems supporting circularity; and (3) the policy and business environment, which considers technological, social, and regulatory factors influencing water circularity technology deployment.

This "mapped system" allows to define a target market in which circular seawater and wastewater products can be successfully integrated. By comparing current and desired market systems, we pinpointed barriers that impede competitiveness, which are then analysed in the Barrier Analysis phase (Nygaard and Hansen, 2015).

Participatory analysis

An important component of this study is co-creation with industry members, as local, regional, and national experts contribute practical knowledge and market insights essential for discussing improvements to market systems for circular seawater and wastewater products. The participatory analysis framework was based on CoP of each case study, through both onsite and online presence. Workshop attendants were trained on the use of Mural,[1] a visual online tool that enables active participation during discussions and brainstorming sessions.

Participatory analysis was first used for the revision of the market maps (initially with a small group of key informants, and later with the CoP), to add actors to the market value chain, as well as relevant aspects to the case study's policy or business environment (e.g., a new policy or regulation). Then, the participation of CoPs was used to revisit the barriers and enablers derived from market mapping, allowing participants to suggest policy instruments to clear up the identified barriers (Figure 1).

This methodology was applied separately for the three assessed technology groups: seawater desalination, urban wastewater treatment and industrial wastewater treatment, each of them consisting of a number of case studies, as can be seen in Figure 2.

[1] https://www.mural.co/

Replication case studies were considered for seawater desalination and industrial wastewater treatment. Replication case studies are not based on a concrete technology development but focus on the condition should the case study solutions be implemented in that specific location.

Results: Identified barriers and measures to overcome them

Technologies were implemented across various regions according to their specific applications: the seawater desalination and urban water reclamation case studies were deployed in coastal, water-scarce areas, while the industrial wastewater treatment case study was located in the heavily industrialized area of Rotterdam. The application of these case studies in areas with characteristics where their large-scale implementation would be most successful facilitated the collection of significant results. The following analysis synthesis the findings drawn by several reports from the WATERMINING H2020 project (WATERMINING H2020 Project, n.d.).

Seawater desalination

Case Study 1: Lampedusa, Italy

The Lampedusa case study focuses on seawater desalination to supply clean water and recover valuable minerals. This initiative combines zero liquid discharge (ZLD) (Muhammad Yaqub and Lee, 2019) desalination with the reuse of extracted resources and integration of waste heat. Purified water produced serves both municipal drinking needs and cooling for nearby diesel engines. The market analysis for Lampedusa includes two main products:

- Water: usable water recovered from seawater serves as coolant, and ice is generated as a by-product via Eutectic Freeze Crystallization (Mazli et al., 2021).

- Recovered salts: Extracted minerals include sodium chloride, magnesium hydroxide, calcium hydroxide, sodium sulfate, hydrochloric acid, and sodium hydroxide, all marketable to various end-users.

This technology holds broad replicability potential across other European islands and beyond (Van der Gaast et al., 2022). The co-creation process followed the steps described in Methods and resulted in the following barriers and measures:

Barriers and measures to address these

EU level

- **Restrictive regulation on sodium chloride for human consumption**: the CoP raised concerns that, per the Codex Alimentarius (Codex Alimentarius Commission, 1992), any salt derived as a by-product of a chemical process cannot be labelled as food-grade, prohibiting consumption. Participants suggested revising legislation to permit human consumption if the sodium chloride meets all Codex safety and quality standards, allowing it to be classified as suitable for dietary use.

National Level

- **Ownership uncertainty in seawater extraction**: the CoP noted ambiguity in seawater ownership as a barrier for desalination market participants. Unlike countries where seawater is a state resource upon extraction, Italy imposes no limits on extraction volumes. Experts suggested monitoring extracted volumes to enable government levies and advocated for reclassifying brine as a resource rather than waste.

Subnational Level

- **Uncertainty in government involvement**: it is unclear which governmental body (EU, national, or local) oversees circular economy and wastewater treatment legislation, and policymakers rarely responded to their queries. However, involvement of regional bodies like Assessorato and ARPA Sicilia was considered crucial for technology approval and environmental permits. The CoP recommended reaching out to similar island regions, such as Pantelleria, to increase local government interest, share insights, and encourage citizen involvement to highlight the social and environmental benefits, potentially attracting further government support.

- **Challenges in monetizing environmental benefits:** the CoP reported difficulties in monetizing the case study's environmental benefits, largely because conventional brine disposal, involving flushing out to sea, is not penalized. They argued that economic viability would improve if the use of conventional brine practices were sanctioned. The CoP recommended conducting analyses comparing circular and linear models to better inform policymakers and attract corporate social responsibility-focused investors. Additionally, expanding the business model to new markets, particularly by promoting awareness of products like recovered sulfates among relevant industries, could further enhance feasibility.

Case Study 2: Almería, Spain

The Almería case study focuses on seawater desalination using renewable energy sources, and mining minerals from brine. A demonstration plant has been built, integrating nanofiltration, multi-effect solar thermal evaporation, and crystallization. The study emphasizes the use of renewable energy for desalination, with a secondary focus on thermal desalination. Purified water will be used for agricultural irrigation. The market system analysis (Wytze van der Gaast and Malte Renz, 2023) was centred around thermal desalination, the supply of treated water for agriculture and the integration of renewable energy systems utilizing residual heat for desalination.

Barriers and measures to address these

National Level

- **Excessive bureaucracy**: stakeholders highlighted the excessive bureaucracy involved in securing government funding for projects similar to the case study. SMEs face significant challenges due to cumbersome paperwork and slow administrative processes for obtaining licenses for water treatment. This is seen as a major barrier, and CoP experts recommended streamlining public administration to simplify application processes, reduce paperwork, and expedite approvals.

- **Lack of investment in R&D by private companies:** the CoP noted that in Spain, most research and development funding comes from the government, with minimal contribution from the private sector. This limited private investment hinders the development of water circularity solutions.

- **Lack of demonstration models:** the CoP highlighted the water sector's conservatism, particularly among irrigation communities, which are used to conventional water treatment methods and hesitant to adopt alternative, innovative technologies, even when beneficial. Explaining these benefits is often insufficient to persuade market actors. Instead, demonstration models, like the one in the case study, are crucial for familiarizing users with the technology and its outcomes, such as water quality. Consulted experts noted a lack of such demonstration projects, hindering the transition from research to market deployment. They recommended increasing the funding for demonstration pilots to showcase the technology's benefits and address potential risks.

Subnational Level

- **Slow implementation of renewable energies:** it was highlighted that the adoption of renewable energy technologies, such as those for seawater desalination in Almería, is hindered by a lack of incentives. The CoP called for stronger policy to support such incentives in order to promote the use of renewable energy in water treatment, particularly given the region’s abundant solar energy resources.

- **Suboptimal water sector governance:** the CoP noted that while Spanish ministries have clear objectives, communication with governing bodies and agencies, including in the water sector, is often inadequate. This leads to delays or partial implementation of the government’s Hydrological Plans at the regional level. Recommendations include streamlining water sector governance to improve integration between national plans and regional execution.

- **Illegal water extraction:** illegal water tapping by end users is widespread, leading to significant amounts of desalinated water being unpaid for. This undermines the financial viability of circular, renewable energy-based water treatment. The CoP recommended creating an inventory of water withdrawals in Almería to identify unpaid water usage and, based on this data, implement regulations to control water extractions.

- **High initial investment costs:** incentives would also contribute to clearing another identified key barrier; the relatively high upfront investment costs for the combined solution of renewable energy and seawater desalination (compared to conventional technologies).

Case Study 3: Replication case study in Greece

A replication case study in Greece examined the feasibility of implementing desalination solutions under local conditions, though it did not involve a specific technology deployment. Driven by high demand for desalination, especially among Greek island communities facing critical freshwater shortages, the study evaluated the potential impact of ZLD technology. ZLD could mitigate environmental issues linked to conventional desalination, such as brine discharge, which threatens local tourism by polluting coastal areas.

Given the absence of an active case study, a workshop gathered regional water authorities from Chios, Ios, and Poros, and government representatives from Greece and Cyprus. Participants identified national investment barriers to desalination advancements, particularly under Greece's current market system.

National Level

- **Marketing recovered products:** Greek municipal water companies, as not-for-profits, lack incentives to market seawater treatment by-products like sodium chloride. To address this, workshop participants suggested public-private partnerships, enabling private companies to commercialize these "water-mined" products for profit, thereby making the circular economy approach more viable.

- **Forest legislation:** a significant barrier identified was strict forest legislation, which complicates environmental licensing for renewable energy installations, such as solar or wind, necessary for desalination plants. While rooftop solar panels on desalination facilities were suggested, this would only partially meet the energy needs. The CoP proposed easing forest regulations to allow larger renewable energy installations.

- **Lack of good practice for membrane crystallizers:** membrane crystallizer technology for magnesium and calcium recovery is unfamiliar in Greece. The involved experts suggested introducing successful European examples to help familiarize local stakeholders.

Urban wastewater treatment

Case Study 4: Faro-Olhão, Portugal

This case study explores the extraction and valorization of Kaumera (P.K Wilfert and et al, 2024) from urban wastewater streams, alongside providing clean water. Kaumera is a novel biopolymer that has various applications, particularly in agriculture (as a binder for fertilizers) and the building sector (e.g., flame-retardant foam, medium-density fibers). The environmental impacts of Kaumera may vary depending on its application.

Kaumera production from wastewater helps reduce excess sludge, lowering disposal costs for wastewater treatment plants. It can be produced in plants using Nereda® technology, which generates Aerobic Granular Sludge, a key component for extracting Kaumera. Currently, two Kaumera demo installations exist: one at the Nereda plant in Utrecht, Netherlands, and another in Faro, Portugal.

Barriers and measures to overcome them

National Level

- **Market reluctance for wastewater-derived products:** the CoP highlighted market hesitation toward Kaumera, a product from wastewater treatment, due to concerns about odour, pathogens, and organic content. To address these perceptions, they recommended raising awareness through transparent information on product safety and production, along with visits to production facilities and application sites to build trust among potential users.

- **Difficult for Kaumera to compete with conventional products**: Kaumera struggles to compete with conventional products due to high production costs and limited economies of scale. The CoP emphasized

improving energy efficiency, generating on-site energy, and increasing market awareness to reduce costs and scale production. The lengthy and costly licensing process also hinders competitiveness. Adapting the product, such as making it more suitable for agriculture, was suggested to meet user needs and broaden its market appeal.

- **Limited experience with Kaumera**: the CoP noted challenges in guaranteeing consistent Kaumera quality, citing limited case study evidence. They called for more pilot projects to enhance quality, support R&D, and demonstrate practical applications, particularly in agriculture.

Case Study 5: Larnaca, Cyprus

The Larnaca case study focuses on R&D and demonstration of phosphorus removal from urban wastewater, using membrane treatment powered by renewable energy and ZLD for brine elimination. The recovered phosphorus and salts can be marketed for various applications, while the purified water is intended for agricultural irrigation.

Barriers and measures to address these

National Level

- **Acceptance of 'mined' products:** the CoP identified market acceptance of phosphorus and salts from circular water treatment as a key barrier to market penetration. Gaining trust is crucial, and experts suggested that local authorities could help by providing material safety data sheets to ensure product quality and safety, boosting buyer confidence.

- **Legal aspects connected to using recovered water:** the CoP emphasized the need for clear legislation in Cyprus regarding minimum irrigation water parameters for different crops. If wastewater treatment water fails to meet these standards, urban wastewater plants should be allowed to propose cleaning processes instead of storing the water in lagoons. Stricter penalties for non-compliance and a revision of regional regulations were also recommended.

Subnational Level

- **Difficulties with business models:** the CoP expressed concerns about developing a viable business model for the proposed circular wastewater treatment due to the low current cost of agricultural water, which would (unfortunately) rise with the new treatment process. They suggested subsidies to offset the cost gap and recommended generating onsite renewable energy to cover the energy needs for phosphorus recovery and ZLD treatment.

Case Study 6: La Llagosta, Spain.

The case study in La Llagosta, Spain, demonstrates technologies for phosphorus recovery and water reuse from urban wastewater, targeting applications from street cleaning to agriculture and industry. Using technologies like a granular anaerobic membrane bioreactor, a fluidized bed vivianite crystallizer, and Biophree (Zheng et al., 2023), the plant aims to establish a pilot-scale treatment model for sustainable phosphorus and water recovery and to explore energy recovery through biogas production from organic wastewater content.

Barriers and measures to address these

EU Level

- **Insufficient regulations for recovered products:** current regulations restrict the reuse of phosphorus recovered from wastewater, often classifying it as waste, which limits its application in another value chain. A proposed EU amendment would allow certain forms, like struvite and vivianite, as fertilizers, though others remain restricted and costly to dispose of. Additionally, wastewater outputs are not classified as urban waste, disqualifying them from subsidies, though the CoP suggests using sludge for biogas or as a sustainable agricultural fertilizer. Strengthening enforcement on illegal waste discharge and ensuring sludge quality could improve trust and support circular practices. The CoP also noted the need for water consumption limits to

manage demand as purified water availability grows, citing Tarragona's successful mandate to use reclaimed water over traditional sources.

Subnational Level

- **Lack of familiarity among market actors and end-users**: to improve familiarity with circular wastewater products, the CoP recommends building alliances across the entire value chain, helping market actors adopt roles beyond waste handling, such as production and distribution. Demonstrations, like those in Barcelona, have shown that showcasing product quality can reduce end-user reluctance. To foster societal acceptance, communicating the sustainability benefits and ensuring quality standards are crucial. Public visits to the La Llagosta pilot plant could further build awareness and trust in these innovative solutions.

- **Lack of economic feasibility**: the CoP noted that circular wastewater treatments are generally costlier than traditional methods, with economic viability further hindered by fluctuating seasonal water demand and regional variations. Scaling up capacity risks underutilization during low-demand periods, while costs are also driven up by illegal waste discharges, which affect wastewater quality and complicate treatment.

Industrial Wastewater Treatment

Case Study 7: Westlake Epoxy, The Netherlands

The pilot plant Westlake Epoxy at the Port of Rotterdam, Netherlands, tests high-pressure oxidation for organic removal, waste heat integration, and innovative ZLD desalination. The products generated (purified brine and recovered salts) can be supplied to industrial applications. For example, companies using fresh brine for electrolysis processes could potentially switch to industrial brine produced through circular wastewater treatment.

Barriers and measures to address these

EU level

- **Uncertainty about end-of-waste criteria for recovered materials from industrial wastewater:** this uncertainty could be addressed by EU-level policies classifying these resources while setting quality standards. The CoP debated whether labelling should be voluntary or mandatory, with voluntary labels effective if adopted with existing market standards. The second CoP meeting recommended a gradual ban on landfilling and surface water discharge of by-products, promoting circular solutions. Participants also suggested BREF documents for circular industrial wastewater treatment to establish best practices in the sector.

National Level

- **Lack of experience in market actors:** circular wastewater treatment can shift market relationships from traditional supplier-customer models to circular partnerships, as seen with Westlake Epoxy and Nobian, where brine replaces salt and quality control shifts. CoP participants recommended leveraging experience or external consultants to facilitate agreements within the value chain. They also suggested EU cooperation on establishing standards for mined products to enable trade across member states.

- **Slow bureaucracy:** long and disorganized permission processes hinder the implementation of industrial water circularity technologies, as seen in the Westlake Epoxy case with a 1.5-year delay for an environmental permit. Delays are due to municipal budget and staffing shortages. The CoP proposed creating an EU unit to assist with obtaining permits for circular wastewater technologies, but some suggested integrating this into an existing EU unit instead.

Subnational level

- **Economical unfeasibility of industrial water circularity under current economic conditions:** circular industrial wastewater treatment is economically unfeasible due to higher costs of industrial brine and uncertainty around cleaning costs. The CoP recommended more R&D, government support, and subsidies to bridge the cost gap. Enforcement against untreated wastewater disposal could be made more effective with higher fines. Policy measures should set safety standards for recovered substances and require minimum water

recovery rates. CO_2 emission reductions from circular treatment could be incentivized by taxing emissions from wastewater reclamation, making low-emission processes more competitive.

Case Study 8: replication case study in Germany

The replication study in Germany focuses on integrating digitalization tools into industrial wastewater treatment. These tools support circular solutions, enhance resource efficiency, and improve sustainability through better Environmental Social Governance (ESG) practices.

EU level

- **Lack of standardisation:** the lack of standardization in protocols, communication, and architectures for digital tools hinders integration across the water treatment supply chain. Manufacturers often use proprietary standards, making it difficult to link systems like sensors and AI. To address this, the Cop suggested policy actions such as standardizing digital tools across the market and facilitating data exchange and machine-to-machine communication to improve water quality monitoring.

Subnational level

- **Lack of clarity in the evaluation of investments:** the lack of clarity in evaluating digitalization investments, due to high initial costs and limited examples, hinders implementation. CoP participants recommended state-funded consulting firms to guide companies and suggested cost-reduction strategies like leasing systems and outsourcing data analysis. Regulations on emissions could also encourage investment in digitalization to meet circular water treatment goals.

- **Cybersecurity risks**: the CoP raised concerns about network and cyber security when implementing digitalization in industrial wastewater treatment. Protecting both internal and external data, as well as company trade secrets and employee "know-how," is crucial. There is a lack of familiarity with available data security solutions, indicating a need for more information on cyber risks and protection measures for market actors.

- **Silo mindsets:** silo thinking within water management value chains hampers collaboration and data exchange on circular wastewater treatment. Participants suggested that governments set a timeline for publishing water quality and environmental data, as well as establish real-time online systems for tracking compliance with these criteria.

Discussion

The findings suggest that common barriers to circular water treatment technologies revolve around too strict regulations, insufficient market incentives and lack of public awareness. At the European level, mainstreaming regulations across member states, particularly for end-of-waste criteria and product quality standards is essential. At the national level, support for demonstration projects and clearer guidelines on product acceptance would significantly enhance market penetration. Local-level interventions should focus on improving administrative capacities and increasing public awareness of the environmental and economic benefits of circular water technologies.

CoP discussions made it clear that some barriers are constant across different technologies and locations, while other restraints apply only to certain technologies and locations. This section presents a summary and analysis of these barriers:

Overarching barriers and measures

The analysis of CoPs responses resulted in the following common challenges across case studies and technologies:

- **Legislative and regulatory challenges**: across cases studies, EU, member-state and regional regulatory restrictions sometimes limit the use of recovered materials as products. Recovered substances are frequently legally classified as waste, which cannot be used in anther value chain, restricting their marketability. In addition, slow bureaucratic approval of permits and unclear ownership definitions further hinder progress. Developing unified EU standards for recovered products and easing regulations could facilitate their classification as marketable goods and reduce regulatory fragmentation across member states.

- **Economic feasibility**: high costs are a consistent challenge, as circular water treatments generally require significant initial investment and often lack sufficient subsidies or incentives. This is seen in both desalination and wastewater mining projects, which face competition from less expensive, conventional water treatment methods.

Financial incentives such as tax benefits and direct subsidies for renewable energy integration, recovered products, and technology development were all proposed as solutions by the CoPs.

- **Market and public perception**: hesitation among market actors and the public around products derived from waste sources, such as the biopolymer Kaumera or phosphorus derived from wastewater, is a common barrier. Concerns often stem from perceived risks associated with safety and hygiene.

Raising public and market awareness about the safety, quality, and environmental benefits of recovered products through transparent information dissemination and encouraging public-private partnerships to commercialize recovered by-products were suggested solutions to this issue.

- **Lack of demonstration models:** linked to the previous point, adoption of new technologies suffers due to limited demonstration projects, particularly for seawater desalination, which are essential for familiarizing users and gaining stakeholder support.

Scaling up pilots and demonstrations to showcase effectiveness, cost savings and efficiency improvements can help reduce perceived financial risks and build confidence among various stakeholders.

- **Governance and bureaucratic inefficiencies**: local governance issues, such as excessive bureaucracy, insufficient public funding, and coordination challenges across regulatory bodies contribute to delays and resistance.

Simplifying administrative procedures, including the issuing of environmental permits, and enhancing coordination among regulatory bodies could speed up project approvals, as well as introducing training for regulatory authorities, industry actors, and engineers to familiarize them with circular water technologies.

Specific barriers and measures

Besides the cross-cutting barriers explained above, there are significant obstacles that are location and technology specific. Among these we find:

Seawater desalination

Lampedusa, Italy

- **Unclear ownership of extracted seawater:** regulatory gaps make it difficult to manage and regulate seawater extraction effectively. Implementing monitoring systems and classifying brine as a legally defined resource to encourage regulated extraction and utilization could help addressing this issue.

Almería, Spain

- **Illegal water extraction:** unregulated tapping of freshwater from water reservoirs hinders the financial sustainability of desalinated water. Documenting water withdrawals and implementing stricter regulations would disincentivize this practice and ensure fair pricing support for desalinated water.

- **Resistance to renewable energy:** there is a slow adoption of renewables due to insufficient local incentives despite suitable environmental conditions for solar energy installations. Enhancing incentives for solar-powered desalination to align with the region's abundant solar resources would help overcome this resistance.

Greece

- **Forest legislation**: forest conservation laws restrict the installation of renewable energy sources crucial for desalination plants. The CoP suggested amending these laws to enable renewable energy installations in areas critical to desalination plant operations.

Urban wastewater treatment

Faro-Olhão, Portugal

- **Market reluctance towards Kaumera:** concerns about odour, safety, and the origins of wastewater-derived products limit their adoption. The CoP recommended building market confidence through education on product safety and quality, as well creating conditions to take advantage of economies of scale to reduce the production cost of Kaumera.

Larnaca, Cyprus

- **Legislative gaps for recovered water use**: inadequate regulations on irrigation water standards impact the acceptability of treated water among stakeholders and market actors. Participants suggested allowing water treatment plants to propose additional cleaning methods for irrigation water that doesn't meet quality standards.

Industrial wastewater treatment

Rotterdam, Netherlands

- **Economic feasibility of industrial wastewater recycling:** the high implementation and operational costs of this technology in The Netherlands make industrial wastewater treatment uncompetitive without subsidies. Increasing government subsidies and introducing penalties for untreated wastewater disposal could incentivize the competitive advantage of circular solutions.

Ethics and consent

This study formed part of the Horizon 2020 WATERMINING project (Grant Agreement No. 869474). The stakeholder engagement activities reported in this manuscript were conducted in accordance with the project's ethical framework and data management procedures (see Data Availability), and institutional ethics committee approval was not required for this study. Ethical oversight was provided through the project's ethical governance structure, coordinated by the Project Management Team, rather than by a separate institutional ethics committee. Participants were provided with the information required under Article 13 of the General Data Protection Regulation (GDPR) before participating, and written informed consent was obtained from all participants. Only anonymised data were used in the analyses.

Data availability

The datasets analysed in this study are publicly available at the Cordis Europe project results website at https://cordis.europa.eu/project/id/869474/results (WATERMINING H2020 Project). These data were generated as part of the EU-funded WATERMINING project.

Acknowledgements

The authors would like to thank the WATERMINING project partners for providing a platform to expand our views on sustainable water circularity solutions, and to all current and past collaborators whose input made this study: Malte Renz (JIN), Jeff Dodick and Ehud Segal (JIPR), Juan Alberto Turnes and Ángeles Pereira (USC), Gonzalo Gamboa and Moises Subirana (UAB), and Ellen Tuinman (Hexion).

References

Commission, J.F.C.A: *Codex Alimentarius.* Food & Agriculture Org; 1992.

European Commission: **Circular economy action plan.** 2020a.

European Commission: **Regulation (EU) 2020/741 of the European Parliament and of the Council of 25 May 2020 on minimum requirements for water reuse.** 2020b.

European Commission: **The European Green Deal [WWW Document].** 2019. (accessed 6.30.26).
Reference Source

Garrote L, Iglesias A, Granados A: **Country-level assessment of future risk of water scarcity in Europe.** *Proceedings of IAHS. Presented at the Innovative water resources management – understanding and balancing interactions between humankind and nature - 8th International Water Resources Management Conference of ICWRS, Beijing, China, 13– 15 June 2018.* Copernicus GmbH; 2018; pp. 455–462.
Publisher Full Text

Hellin J, Griffith A, Albu M: **Mapping the market: market-literacy for agricultural research and policy to tackle rural poverty in Africa.** 2005.

Mazli WNA, Samsuri S, Mohamad Annuar A: **Eutectic freeze crystallization: application, process design and future potential.** *IOP Conf. Ser.: Earth Environ. Sci.* 2021; **765**: 012098.
Publisher Full Text

Yaqub M, Lee W: **Zero-liquid discharge (ZLD) technology for resource recovery from wastewater: A review.** *Sci. Total Environ.* 2019; **681**: 551–563.
PubMed Abstract | **Publisher Full Text**

Nikas A, Doukas H, Lieu J, *et al.*: **Managing stakeholder knowledge for the evaluation of innovation systems in the face of climate change.** *JKM.* 2017; **21**: 1013–1034.
Publisher Full Text

Nygaard I, Hansen UE: *Overcoming Barriers to the Transfer and Diffusion of Climate Technologies, TNA Guidebook Series.* UNEP DTU Partnership; 2015.

Wilfert PK, *et al.*: *Kaumera Methods Manual: A comprehensive guide to lab extraction and characterization methods for extracellular polymeric substances (EPS).* Delft University of Technology; 2024.

UNDP: **Technology Need Assessment Handbook.** 2010.

van der Gaast W: **Towards a Future Climate Policy—From the Kyoto Protocol to the Paris Agreement.** van der Gaast W, editor. *International Climate Negotiation Factors: Design, Process, Tactics.* Cham: Springer International Publishing; 2017; pp. 91–123.
Publisher Full Text

van der Gaast W, Renz M, Panteleaki-Tourkodimitri K, *et al.*: **Deliverable 9.1 Market System Maps Related Work Package WP 9 Deliverable lead JIN.** 2022.

WATERMINING H2020 Project: **WATERMINING Project Results.** n.d.
Reference Source

Wytze van der Gaast, Malte Renz: **WATERMINING Deliverable 9.6.** 2023.

Zheng Y, Wan Y, Zhang Y, *et al.*: **Recovery of phosphorus from wastewater: A review based on current phosphorous removal technologies.** *Crit. Rev. Environ. Sci. Technol.* 2023; **53**: 1148–1172.
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Open Peer Review

Current Peer Review Status: ✗

Version 1

Reviewer Report 12 September 2026

https://doi.org/10.21956/openreseurope.26509.r79988

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✗

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Reviewer: Prof. Dr. Alfonso Expósito García
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Manuscript: ***Identified barriers and solutions for sustainable water in Europe: an analysis of seawater and wastewater mining***

The manuscript examines six demonstration case studies and two replication studies involving seawater desalination, urban wastewater treatment and industrial wastewater treatment across several European countries. The analysis is based principally on market system analysis and co-creation workshops conducted within the WATERMINING project.
The manuscript addresses an important challenge. Technological solutions for water circularity cannot be assessed solely on their technical performance; regulatory frameworks, institutional arrangements, market conditions, economic viability, public acceptance and stakeholder coordination can ultimately determine whether technologies move beyond pilot and demonstration stages. A comparative assessment of these barriers across technologies and territorial contexts is therefore potentially valuable.
The manuscript also benefits from the direct participation of actors involved in the implementation of the technologies. Nevertheless, the paper currently reads in places more as a synthesis of project case-study findings than as a fully developed scientific cross-case analysis. The scientific contribution would be considerably strengthened by clarifying the research design, explaining how evidence from the workshops was analysed and synthesised, providing greater transparency regarding participants and case selection, and developing a more analytical discussion of the results.
I recommend that the authors consider the following comments.

Major comments

1. The novelty and research contribution need to be defined more explicitly.
The Introduction states that previous research has concentrated largely on technological performance, energy efficiency, environmental impacts and life-cycle assessment, while paying less attention to institutional, regulatory, economic and market conditions. This is a plausible research gap, but it is currently asserted rather than demonstrated.
The authors should strengthen this section with a more systematic engagement with the literature on barriers to water reuse, desalination, resource recovery, circular-economy technologies, innovation adoption and technology upscaling. This would allow the manuscript to demonstrate more clearly what is already known and precisely what this study adds.
It is particularly important to explain the new scientific contribution of this paper relative to the WATERMINING project deliverables on which much of the evidence appears to be based. Page 5 explicitly states that the analysis synthesises findings from several WATERMINING reports. The authors should therefore state clearly what new analytical work has been undertaken for the article: for example, whether the cross-case classification, comparison of barriers, synthesis of measures or higher-level typology was developed specifically for this manuscript.

2. The methodology requires considerably greater transparency and reproducibility.
This is the most important issue in the manuscript. The authors explain the broad process (preliminary market mapping followed by several iterations of participatory analysis) but insufficient information is provided about how the empirical evidence was actually produced.
A reader should be able to determine, for each case study, how many workshops were held; when they took place; how many people participated; how participants were selected and recruited; which stakeholder groups were represented; whether the same participants attended successive iterations; whether workshops were online, face-to-face or hybrid; how long they lasted; how discussions were recorded; and how the resulting qualitative information was analysed.
This is essential because the manuscript currently refers generally to “experts”, “industry experts” and Communities of Practice, although Figure 1 indicates a considerably broader composition including researchers/users, private companies, public-sector bodies, environmental agencies and NGOs. The terminology should accurately reflect the actual participant population.

3. The analytical procedure used to move from workshop findings to “overarching barriers” is insufficiently explained.
The Methods state that conclusions were “analysed and aggregated as overarching or specific”, but the procedure used to do this is not described. This is central to the paper because the main contribution is precisely the identification of cross-cutting barriers.
The authors should explain whether they undertook thematic coding, content analysis or another qualitative synthesis method; how categories were created; whether a coding framework was defined in advance or emerged inductively; whether more than one researcher coded the material; how disagreements were resolved; and what criterion determined that a barrier was “common” or “cross-cutting”.
At present, statements such as “a consistent challenge” or “common barrier” are difficult to evaluate. I strongly recommend adding a cross-case matrix showing which barriers were identified in each case. This could reveal, for example, whether “regulatory uncertainty” occurred in six of eight cases whereas “public acceptance” occurred in three. It would make the synthesis much more transparent without attempting inappropriate statistical inference from a small qualitative sample.

4. The rationale for the case-study and replication-study design should be explained.
The distinction between six demonstration cases and two replication cases is important but underdeveloped. The paper states that the replication cases in Greece and Germany do not involve specific technology development but assess conditions under which technologies could be implemented.
The authors should explain why Greece and Germany were selected as replication cases, what selection criteria were used, and why replication was undertaken for desalination and industrial wastewater treatment but not for urban wastewater treatment. This is particularly important for the comparability of the eight cases.
It should also be clarified whether evidence from a hypothetical replication context can legitimately be treated as equivalent to evidence arising from actors directly involved in operating a demonstration installation. I would not necessarily exclude the replication cases, but the analytical distinction should be explicit.

5. Results derived from stakeholder perceptions must be clearly distinguished from externally verified facts.
This is a recurrent issue throughout the paper. Several statements originating from the CoPs are subsequently written as factual descriptions of national or regional conditions. The authors should be very careful not to transform stakeholder perceptions into established empirical facts unless independent evidence is provided.
For example, the Almería case states that most R&D funding in Spain comes from government and that private-sector contributions are minimal. This is a substantial empirical claim and needs supporting data or an appropriate reference. Otherwise, it should be written as: “Workshop participants perceived insufficient private-sector investment in R&D as a barrier”.
The same principle should be applied throughout the paper. Phrases such as “participants reported”, “the CoP perceived”, or “stakeholders identified” would make the evidential status of these findings much clearer.

6. Several interpretations in the Almería case need reconsideration or stronger substantiation.
I share the concerns already marked in the manuscript regarding this case. The description of the water sector — and irrigation communities in particular — as conservative and reluctant to adopt alternative technologies appears too general. Almería is precisely a territory where irrigated agriculture has substantial experience with non-conventional resources, including desalination and reclaimed water. The authors therefore need either to provide evidence supporting the more specific form of reluctance identified by participants or substantially qualify the statement. See for example the irrigators association of Cuatro Vegas, which has made considerable investments in desalination and water reclamation plants. Similarly, the claim concerning “lack of investment in R&D by private companies” requires evidence, as noted above.
The statement that illegal water extraction results in “significant amounts of desalinated water being unpaid for” is especially unclear. Illegal abstraction of conventional resources and non-payment for desalinated water are conceptually different problems. The mechanism through which one causes the other needs to be explained. If participants were referring to illegal groundwater abstraction undermining demand for — and therefore the financial viability of — desalinated water, this should be stated explicitly.
Finally, the characterisation of renewable-energy uptake as being constrained principally by a lack of incentives should be reconsidered or supported by evidence. There have been important public

programmes supporting irrigation modernisation and renewable-energy investment. The issue may instead concern the adequacy, accessibility or continuity of existing incentives for this particular technological configuration. That would be a more defensible formulation than implying that incentives are absent. See, for example, following link: https://www.mapa.gob.es/es/prensa/ultimas-noticias/detalle_noticias/el-ministerio-de-agricultura-pesca-y-alimentaci-n-destina-24-millones-de-euros-a-la-modernizaci-n-de-los-regad-os-de-aguas-del-almanzora-/65612f2e-973f-424d-af71-212e7f3afaac

7. The case-study descriptions should be made more consistent.
There is substantial variation in the amount of technological and contextual information provided for each case. The Lampedusa section, for example, gives a broad description of ZLD, resource recovery and waste-heat integration, but the actual treatment configuration and demonstration context remain relatively general. By contrast, the La Llagosta section names several individual technologies, including a granular anaerobic membrane bioreactor, vivianite crystallisation and Biophree. A standard short description should be provided for every case covering the feedwater/wastewater source, technology, scale or development stage, recovered products, intended users, and local implementation context.
This is particularly necessary for La Llagosta, where additional contextual information would help readers understand why the identified market and regulatory barriers arise.
The German replication study is also geographically underspecified. It is presented simply as a replication study “in Germany” focusing on digitalisation. If it is associated with a particular industrial cluster, region or set of actors, that should be stated. If the analysis was intentionally undertaken at national level, this should be explained and contrasted with the much more geographically specific demonstration cases.

8. The Cyprus interpretation requires more careful contextualisation.
The manuscript identifies “legislative gaps for recovered water use” and suggests that inadequate irrigation-water regulation affects acceptance. This formulation is difficult to reconcile with Cyprus's long-standing strategic use of reclaimed wastewater for irrigation. The authors should clarify exactly which regulatory gap participants identified. Is the problem the absence of regulation for reclaimed water generally, or rather uncertainty surrounding specific quality parameters, treatment configurations, crops, recovered products or compliance procedures? These are very different claims. This is a good example of why the paper should distinguish between a general national policy context and a technology-specific barrier identified by workshop participants.

9. The Results section is overly descriptive and the Discussion repeats much of it.
Pages 5-10 provide a long case-by-case catalogue of barriers and proposed measures. The Discussion then restates many of the same issues under overarching and case-specific headings. This produces repetition without sufficient additional interpretation. I suggest reorganising the manuscript so that detailed case-level findings are condensed into one or two tables. The prose Results could then concentrate on patterns revealed by the cross-case analysis.
The Discussion should do something different: explain *why* certain barriers recur across technologies; compare the findings with the existing literature; consider differences between desalination and wastewater mining; examine whether barriers vary according to governance level or technological maturity; and discuss implications for European policy and innovation systems. At present, the Discussion is largely another summary of the findings rather than an interpretation of their significance.

10. The concept of governance scale requires greater consistency.
The classification of barriers as “EU level”, “National Level” and “Subnational Level” is potentially useful, but the criteria are unclear and do not appear to be applied consistently. For example, administrative delays attributed to municipal staffing constraints are discussed within a national-level subsection in the Dutch case. Other issues potentially involving EU legislation, national implementation and local permitting are assigned to a single scale.
The authors should explain whether the level refers to the origin of the barrier, the authority competent to solve it, or the territorial scale at which participants experienced it. A multilevel-governance perspective may actually be more appropriate for several barriers, since many arise from interactions between EU regulation, national transposition and regional/local implementation.

11. Several regulatory and legal assertions require independent verification and references.
Because regulation is one of the paper's central barrier categories, legal claims need to be particularly precise. Examples include the interpretation of Codex Alimentarius rules concerning recovered salt; seawater ownership and extraction in Italy; the classification of recovered phosphorus or sludge; forest legislation in Greece; and the regulatory status of recovered industrial products. These statements may accurately reflect participant perceptions, but if presented as descriptions of the applicable legal framework they should be verified against primary legal or regulatory sources.
This is especially important because one of the paper's conclusions is that regulations are sometimes “too strict”. In some cases the problem may not be excessive regulation per se, but regulatory uncertainty, fragmented competences, absence of end-of-waste criteria, lengthy permitting or inappropriate application of existing rules. These distinctions matter for the resulting policy recommendations.

12. “Solutions” should generally be presented as proposed measures or enabling actions rather than demonstrated solutions.
Most measures reported in the article originate from workshop discussions. They have not, as far as the manuscript demonstrates, been implemented and evaluated. Consequently, terms such as “proposed measures”, “enabling measures”, “policy options” or “stakeholder-proposed responses” would be more precise than “solutions”. This applies both to the section headings and potentially to the title. A possible title would be: “Barriers and enabling measures for scaling circular water technologies in Europe: a cross-case analysis of seawater and wastewater mining”. This would also be more precise than the rather broad expression “sustainable water”.

13. The paper needs an explicit limitations section.
The manuscript should acknowledge at least the following limitations: the relatively small and purposively selected expert samples; unequal stakeholder representation between cases; possible self-selection bias; the involvement of project actors in both technology development and evaluation; the heterogeneity of technologies and maturity levels; the combination of demonstration and replication cases; the uneven geographical scale of the cases; and the reliance on stakeholder perceptions for some claims.
It would also be useful to discuss transferability. Eight project cases cannot by themselves establish the barriers to circular water technologies across “Europe” as a whole. The findings can identify recurrent barriers across the cases studied, from which potentially wider implications can be developed. The Abstract and conclusions should avoid implying statistical or comprehensive

European representativeness.

14. A dedicated Conclusion section would improve the article.
The manuscript moves from the detailed Discussion directly to Ethics and consent. I recommend adding a short Conclusion that clearly states the main cross-cutting finding; the principal differences between technology groups or contexts; the key practical/policy implication; the limitations of generalisation; and the contribution of the cross-case methodology.

15. Data availability should be described more precisely.
The Data Availability statement says that the datasets analysed are publicly available through the CORDIS project-results webpage. It is not clear, however, whether this refers to the actual anonymised workshop material used in the analysis, processed barrier datasets, or merely the WATERMINING deliverables. The authors should identify the precise datasets supporting the manuscript and ideally provide direct references to them. If raw workshop data cannot be made public because of participant confidentiality, this should be stated, together with information on which processed/anonymised data are available.

Minor comments
The manuscript would benefit from a thorough language edit in British English. There is currently a mixture of British and American forms, for example *valorisation* alongside *monetizing*, *utilizing*, *familiarizing* and *standardization*.
On page 3, the sentence “An overview of the process followed in this study can be seen in.” is incomplete; the intended reference is presumably Figure 1.
The term “CoP assistants” should be replaced by CoP participants or workshop participants.
“The following analysis synthesis the findings” should be “The following analysis synthesises the findings”.
The use of “economical unfeasibility” should be replaced by “lack of economic viability”.
References and in-text citations require careful checking. Examples such as “P.K Wilfert and et al”, author forenames being used instead of conventional surname citation, and inconsistent formatting of project deliverables should be corrected.
Figure 1 could be made more self-explanatory.

AI-use statement: GPT-5.6 Sol (OpenAI) was used for limited language improvement and proofreading. The review content remains the author’s own.

Reviewer: Esther Díez-Cebollero, PhD.
Affiliation: Water, Environmental and Agricultural Resources Economics (WEARE) research group (University of Córdoba, Spain) and Centre for Research in Agricultural Genomics (Catalunya, Spain). Email: **esther.diez@cragenomica.es.**
Title: *Identified barriers and solutions for sustainable water in Europe: an analysis of seawater and wastewater mining*

This manuscript addresses an important and policy-relevant topic: the conditions under which desalination, wastewater reuse, and resource recovery can contribute to more circular and resilient water systems in Europe. The paper benefits from a broad geographical scope, the inclusion of seawater, urban wastewater, and industrial wastewater cases, and the attempt to combine market-system analysis with stakeholder co-creation. The focus on barriers beyond purely technical performance is potentially valuable, particularly because institutional, regulatory,

financial, and societal conditions often determine whether promising technologies move beyond the demonstration stage.
The manuscript is also timely in relation to the European policy agenda. The European Water Resilience Strategy, adopted in 2025, explicitly promotes restoration of the water cycle, a water-smart economy, water reuse, digitalisation, innovation, investment, and improved governance. The paper's subject is therefore closely connected to current European priorities. Nevertheless, the manuscript presents significant shortcomings that require special further attention. Please see my comments below:

Major comments
1. The contribution is relevant but insufficiently distinguished from existing research
The topic is clearly relevant, but the manuscript does not yet demonstrate convincingly what new knowledge it contributes. Barriers to water reuse, desalination, brine management, nutrient recovery, wastewater-derived products, public acceptance, regulatory fragmentation, and the transition from pilots to market deployment have been widely discussed in academic and policy literature. The authors should clarify whether the novelty lies in: comparing barriers across seawater desalination, urban wastewater treatment, and industrial wastewater treatment; linking barriers to specific levels of governance; identifying barriers associated with the commercialisation of recovered products; integrating demonstration and replication cases; or generating policy recommendations from stakeholders directly involved in implementation.

At present, all these possibilities are mentioned, but none is developed as the central contribution. The manuscript would benefit from a concise contribution statement at the end of the introduction. For example, the authors could explain that the study contributes a cross-case comparison of implementation barriers identified through a common stakeholder process, while also acknowledging that it is exploratory rather than statistically representative.
The authors should also engage more directly with existing reviews and comparative studies. A stronger literature review should include research on barriers and drivers of water reuse, social acceptance of reclaimed water and wastewater-derived products, circular economy implementation in the water sector, resource recovery and end-of-waste regulation, desalination sustainability and brine valorisation, water-energy-food-ecosystems nexus approaches, and business models for circular water systems.
The authors should also avoid implying that the paper fills a completely neglected research gap. A more accurate formulation would be that the paper provides an applied, cross-case synthesis of known and context-specific barriers, based on a common participatory process.

2. The manuscript does not adequately discuss ongoing European projects and initiatives
The paper is based on the WATERMINING project and repeatedly refers to project deliverables, but it does not sufficiently situate its findings in relation to other ongoing or recently completed European projects. This is a significant omission, especially because the manuscript makes claims about European-scale barriers and replication. Their omission makes it difficult to determine whether the reported barriers are specific to WATERMINING, broadly shared across European projects, or already being addressed through other research and demonstration activities. Hence, the revised manuscript should include a dedicated subsection discussing related European projects and initiatives. This section should not simply provide a list of projects. It should explain which barriers these projects address; whether their approaches confirm or challenge the findings of this paper; whether they provide evidence on replication, financing, regulation, or public acceptance; what lessons can be transferred to the eight cases; and what unresolved gaps remain.

3. The European Water Resilience Strategy should be incorporated explicitly
The manuscript refers to the European Green Deal, the Circular Economy Action Plan, and the Water Reuse Regulation, but it does not mention the European Water Resilience Strategy. This is a major gap, particularly because the paper was published after the Strategy was adopted. The paper should therefore map its findings against the Strategy's objectives and action areas.

4. The methodology is not sufficiently developed or reported
This is the most important methodological concern. The manuscript states that it used market mapping, root-cause analysis, and co-creation workshops, but it does not provide enough information for readers to understand, evaluate, or reproduce the research process. The manuscript should provide substantially more detail on the following points.

Participant selection
The paper describes Communities of Practice comprising researchers, private companies, public-sector organisations, environmental agencies, and NGOs. However, it does not report the number of participants in each case, the number of participants by stakeholder category, the criteria used to invite participants, and the degree to which end-users, affected communities, farmers, utilities, consumers, and regulators were represented. This information is essential because the findings may be shaped by the composition of the workshops. A group dominated by researchers and project partners may identify different barriers from a group dominated by utilities, farmers, industrial customers, environmental regulators, or local residents. The authors should include a participant table for each case, or at least an aggregated table by stakeholder group. They should also discuss possible selection bias and conflicts of interest. The statement that no competing interests were disclosed is not sufficient to establish independence of stakeholder input.

Workshop design
The manuscript should report on the structure of the workshops in greater detail (i.e. duration and number of workshops per case, how market and barriers were identified, and how disagreements were handled). The current description of three iterations is helpful, but it does not explain what data was generated at each stage. The authors should make clear whether the final findings are based on verbatim statements, workshop notes, coded responses, voting results, researcher interpretation, or a combination of these sources.

5. The recommendations need prioritisation and operational detail
The manuscript proposes many reasonable measures, including subsidies, public-private partnerships, regulatory reform, demonstrations, public awareness campaigns, standards, penalties, improved coordination, and training. However, the recommendations are often generic and are not prioritised.
Likewise, the authors should also recognise trade-offs. Subsidies may support early deployment but can create dependency if the underlying business model remains weak. Penalties on discharge may promote circularity but may also impose disproportionate costs on smaller operators. Reclassifying recovered materials as products can improve market access but must not weaken health, environmental, or traceability requirements.

6. The economic analysis is too limited
Economic feasibility is repeatedly identified as a central barrier, but the paper provides no quantitative economic analysis. There are no estimates of capital costs, operational costs, energy

costs, revenues from recovered products, avoided disposal costs, cost per cubic metre, or break-even conditions. Even if a full techno-economic assessment is beyond the scope of the paper, the authors should provide at least a structured economic interpretation.
In addition, the paper should distinguish between financial feasibility for an individual operator and broader societal or environmental benefits. A technology may not be privately profitable but may produce public benefits through reduced freshwater abstraction, lower pollution, improved drought resilience, or reduced emissions. If the authors invoke environmental benefits, they should explain how those benefits could be assessed or monetised.

Minor comments
Introduction
The introduction would benefit from a clearer research question or set of research questions. At present, the objectives are broad. Possible questions include:

Which barriers are perceived as common across the selected technologies and locations?
Which barriers are specific to technology, geography, or governance level?
Which policy and market measures do stakeholders consider most appropriate?
How do demonstration cases differ from replication cases?

Case-study descriptions
The case studies should be presented in a comparative table showing location, technology, water source, recovered resources, intended end use, technology readiness or project maturity, demonstration or replication status, participating stakeholder groups, and principal barriers. This would make the results easier to follow and reduce repetition in the narrative.

Tables and figures
The manuscript would benefit from a table summarising barriers across cases. The current presentation provides extensive narrative detail but makes it difficult to see patterns. A heatmap or matrix.

AI-use statement: GPT-5.6 Sol (OpenAI) was used for limited language improvement and proofreading. The review content remains the author's own.

Is the work clearly and accurately presented and does it engage with the current literature?
Partly

Is the study design appropriate and is the work technically sound?
Partly

Are sufficient details of methods and analysis provided to allow replication by others?
Partly

Are all the source data and materials underlying the results available?
Partly

If applicable, is the statistical analysis and its interpretation appropriate?
Not applicable

Are the conclusions drawn adequately supported by the results?
Partly

Competing Interests: No competing interests were disclosed.

Reviewer Expertise: Water and environmental economics, water policy, water management.

We confirm that we have read this submission and believe that we have an appropriate level of expertise to state that we do not consider it to be of an acceptable scientific standard, for reasons outlined above.