BOOST-IN

Uptake of innovative and circular solutions for water

Regional analysis of policy needs, drivers, enablers, and barriers for implementing Water and Circular Economy Solutions

Deliverable 3.2

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ABSTRACT	The transition towards a water circular economy is increasingly important as droughts, water scarcity and competing demands expose the limits of conventional water systems. This deliverable assesses the performance and uptake of Water Circular Economy Solutions (WACES) by analysing 24 cases based on questionnaires and interviews. Solutions were grouped into families covering monitoring, wastewater treatment (primary to tertiary with disinfection), management and training tools, and resource recovery. In parallel a regional scan across six regions of opportunity identified drivers, enabling factors and barriers influencing adoption. Results show that WACES contribute positively to European policy goals by improving water quality, enabling safe reuse in agriculture and industry, and recovering resources. However, uptake remains limited outside pilot contexts and is constrained by regulatory complexity, lengthy certification processes, fragmented governance, high upfront investment costs and uncertain revenue models. Drivers include water scarcity and economic benefits from nutrient and energy recovery. Key enabling factors are funding mechanisms, cross-sectoral cooperation, simplified permitting, demonstration sites and increasing public awareness. The findings highlight that a coherent policy framework, economic incentives and trust-building through transparent monitoring and stakeholder engagement are critical to accelerate WACES implementation and to strengthen resilience against water-related challenges in Europe.		

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TABLE OF CONTENTS

LIST OF FIGURES 5
LIST OF TABLES 5
ACRONYMS 6
EXECUTIVE SUMMARY 7
1.0 INTRODUCTION 8
2.0 METHODOLOGY 8
2.1 Assessment of WACES performance 9
2.2 Assessment of the regional landscape for WACES implementation 11
3.0 RESULTS OF THE WACES ASSESSMENT 11
3.1 Policies addressed by WACES 12
3.2 Trade-offs, indicating potential policy conflicts 15
3.3 Assessing WACES contributions to circular economy objectives (Effectiveness on the ground) 16
3.4 Efficiency of WACES 17
3.5 Assessing WACES Uptake by identifying implementation barriers 17
3.6 Climate resilience – WACES' ability to withstand climate-related risks 23
4.0 REGIONAL POLICY CONTEXT ANALYSIS 25
4.1 ROp circular economy related policies 26
4.2 ROp policy scoping results 27
4.3 Analysis of WACES contribution to national laws and decrees 27
4.4 Identified barriers per ROp 29
4.5 Drivers 32
4.6 Enabling factors 34
5.0 DISCUSSION 36
6.0 CONCLUSION AND FURTHER STEPS 41
ANNEX I: POLICIES ADDRESSED 42
ANNEX II: TRADE-OFFS 44
ANNEX III: EFFECTIVENESS ON THE GROUND 46
ANNEX IV: ROP RELEVANT CIRCULAR ECONOMY POLICIES 48
ANNEX V: DETAILED BARRIERS OF THE ROPS 50
ANNEX VI: DETAILED DRIVER OF THE ROPS 62
ANNEX VII: DRIVERS, ENABLING FACTORS AND BARRIERS CONNECTED 65

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List of figures

Figure 1: Do the WACES contribute to the different EU policies? 13
Figure 2: Policy addressed per WACES category. 14
Figure 3: Overall performance of the WACES regarding their contribution to EU policies. 15
Figure 4: Overview of the average score per barrier and technology type. 19
Figure 6: Overview if a strategy or a law directly or indirectly refers to a WACES. 27
Figure 7: Overview if a strategy or a law promotes circular economy measures. 27
Figure 8: Overview barrier level in the different categories. 29
Figure 9: Weighted average score per category, revealing the category with the highest barrier level. 30
Figure 10: Overview of the barrier level in the 6 ROps. 30

List of tables

Table 1: Overview of the overall performance of the analysed WACES. 11
Table 2: Legend depicting the colour coding for assessing the WACES contributions. 12
Table 3: Severity of the barrier categories by each of the WACES. 18
Table 4: Description of barrier colour coding. 18
Table 5: Sensitivity of the WACES to the different hazards. 24
Table 6: Description of the climate sensitivity colour coding. 24
Table 7: Vulnerability of the WACES based on their implemented location. 25
Table 8: Description of the climate vulnerability colour coding. 25
Table 9: Overview of the enabling factors that were submitted by the ROps. 34
Table 10: Overview of policies that are addressed by the different WACES. 42
Table 11: Overview of identified trade-offs. 44
Table 12: Overview of measurable contributions of WACES to EU directives 46
Table 13: Overview of the relevant policies for CE submitted by the ROps. 48
Table 14: Overview of the relevant strategies for CE submitted by the ROps. 49
Table 15: Full list of the barriers submitted by each of the ROps. 50
Table 16: Comparison of the identified drivers by the ROps and the WS held at the GA in Bologna. 62
Table 17: Summary table of ROp specific enabling factors, drivers and barriers combined with the barriers identified by the WACES holders. 65

Acronyms

CBA – Cost-Benefit Analysis

CE – Circular Economy

DWD – Drinking Water Directive

ECL – European Climate Law

FD – Floods Directive

GWD – Groundwater Directive

IED – Industrial Emissions Directive

LCA – Life Cycle Assessment

MON – Monitoring

MSFD – Marine Strategy Framework Directive

MTT – Management & Training tools

ND – Nitrates Directive

NRL – EU Nature Restoration Law

RBMP – River Basin Management Plans

RED – Renewable Energy Directive

ROp(s) – Region(s) of Opportunity

RR – Resource recovery

SSD – Sewage Sludge Directive

Taxonomy DA – EU Taxonomy Climate and Environment Delegated Acts

TPS – Treatment: primary/secondary

TTD – Treatment: tertiary & disinfection

UWWTD – Urban Wastewater Treatment Directive

WACES – Water Circular Economy Solutions

WFD – Water Framework Directive

WWTP – Wastewater treatment plant

Executive summary

The transition towards a water circular economy is gaining importance as droughts, water scarcity and competing demands expose the limits of current water systems. Alternative sources such as water reuse can reduce pressure on freshwater bodies, enhance resilience and recover resources. However, their uptake is challenging and requires supporting conditions and contexts, including a coherent policy framework and economic incentives.

This deliverable assesses how well Water Circular Economy Solutions (WACES) are performing in practice and what supports their uptake. Out of a pool of WACES, 24 were selected and analysed based on standardised factsheets, in which the information from written questionnaires and interviews was collected. Furthermore, the WACES were grouped into solution categories, namely monitoring, primary and secondary wastewater treatment, tertiary wastewater treatment with disinfection, management and training tools, and resource recovery to enable anonymised analysis. In parallel, a regional scan across six Regions of Opportunity (ROp) identified drivers, enabling factors and barriers, gathered by a written questionnaire, interviews with the ROp leaders of the BOOST-IN project, as well as stakeholder interviews. The goal was to understand what influences the uptake of WACES and what could make it more successful.

The results show that many solutions can deliver various benefits and contribute positively to European policy, especially the water-related ones. More specifically, i) better monitoring improves compliance and risk management by making quality and safety visible near real time, which further supports operational decisions and improves overall safety; ii) treatment upgrades in wastewater treatment plants at primary, secondary and tertiary stages with disinfection raise effluent quality to levels that enable safe reuse in agriculture and industry while lowering overall pollutant loads; iii) resource recovery from wastewater streams provides an effective pathway to close nutrient loops and increase energy production, for example, via nitrogen and phosphorus recovery and biogas production and iv) management and training tools help operators and authorities to improve performance and knowledge. However, evidence gaps regarding trade-offs show the importance of life cycle assessments and economic benefit analysis to provide a robust basis for decision-making. Outside pilot projects, solutions are mainly implemented in areas where water scarcity or cost pressure is already an acute issue and therefore interconnections between institutions, agriculture and industry are more common.

Besides the potential positive effects, several barriers persist. Regulatory complexity and institutional fragmentation increase project risk and extend timelines, especially when reuse and recovery rules are unclear or overlap. Furthermore, lengthy certification processes for recovered products or legal frameworks that accept monitoring only by a limited set of methods hamper uptake. Also, high upfront capital costs and uncertain revenue models constrain economic viability.

The findings highlight several specific drivers and enabling factors that can accelerate the uptake of WACES. Water scarcity and recurring droughts are powerful drivers, particularly in southern European regions, where reclaimed water is increasingly valued as a reliable supply for agriculture and industry. Economically, the prospect of replacing fertiliser imports through nutrient recovery and reducing energy spend with biogas can create incentives for utilities and farmers. On the enabling side, established funding mechanisms at the EU and national level play a critical role in bridging high upfront costs, while collaborative research projects and demonstration sites reduce uncertainty and build confidence. Cross-sectoral cooperation between water, energy and agricultural stakeholders emerges as another key enabler, helping align interests and pool resources. Simplified and harmonised permitting processes lower transaction costs and reduce delays. Public awareness of climate risks and drought impacts is gradually shifting attitudes in favour of safe water reuse. Transparent communication, visible monitoring results and co-creation with local stakeholders can help to address distrust and build confidence, turning awareness into acceptance and smoother implementation of new reuse and recovery projects.

1.0 Introduction

In recent years, Europe has suffered from various droughts, floods, wildfires and other water-related hazards. There is an increasing trend that those extreme events will be more frequent, and together with a rising water demand will continue to put pressure on natural water resources. This concerning development calls for urgent action, not only in terms of environmental protection but also with regard to more efficient and sustainable water use. In this context Water Circular Economy Solutions (WACES) are gaining importance to address those challenges.

> **Water Circular Economy Solutions** (**WACES**) are strategies and technologies that aim to maximise the efficiency of water (re-)use, minimise waste, recover resources and promote the overall improvement of the quality and quantity within the water cycle.

The successful uptake of a WACES not only depends on the technological readiness but also on the policy framework and the environment in which it is implemented. This may cause barriers that arise from regulatory uncertainties, unclear responsibilities or limited financing. On the other hand, there are also circumstances and factors that can act as enabling factors or drivers, such as political commitment and social acceptance. Understanding these settings and interlinkages is therefore crucial to advancing WACES at regional and national level.

The purpose of this deliverable is to understand these dynamics and provide a regional analysis of the policy needs, drivers, enablers, and barriers for implementing WACES. It builds directly on the policy assessment framework developed in Deliverable 3.1.[1] and extends this work by focusing on the six regions of opportunity (ROps) - which are part of the BOOST-IN project - and their role in the uptake of WACES. Given the central role of the ROps, the data that was used especially to spotlight the regional dimension was provided through the involvement of the project partners from the ROps: Srednogorie in Bulgaria (BWA), Mediterranean coast region in France (ECOFILAE), Lower Saxony in Germany (KWB), Peloponnese in Greece (NTUA), Emilia-Romagna in Italy (UNIBO), and Andalusia in Spain (BIOAZUL).

The document is structured to first present the assessment of WACES performance according to six criteria: Policies addressed, trade-offs, effectiveness on the ground, efficiency, uptake and climate resilience. This provides an overview of how WACES interact with EU policy objectives and the barriers influencing their implementation. The second part of the deliverable turns to the regional dimension. It analyses the policy landscape of the six ROps, reviewing relevant laws and strategies and identifying how they relate to WACES. It further explores region-specific barriers, drivers and enabling factors that condition WACES uptake in practice. The final sections of the deliverable discuss the findings across all ROps, synthesise cross-cutting insights, and outline conclusions on the opportunities and challenges for strengthening the role of WACES in advancing the water circular economy.

2.0 Methodology

This deliverable consists of two parts: The first one assesses the performance of 24 selected WACES based on six criteria (Policies addressed, Trade-offs, Effectiveness on the ground, Efficiency, Uptake, Climate resilience), as defined in Deliverable 3.1. The second part examines the six ROps, identifying enabling factors, drivers, and barriers for WACES implementation, and reviewing laws and strategies relevant to

[1] POLICY ASSESSMENT FRAMEWORK FOR ANALYSING WATER AND CIRCULAR ECONOMY SOLUTIONS (WACES) WITHIN THE BOOST-IN PROJECT - Deliverable 3.1: Assessing the contribution of selected WACES for meeting EU- and National Policy Targets; Link

the water circular economy. Both parts provide insights into WACES performance and the policy and governance conditions which may support or hinder their uptake.

2.1 Assessment of WACES performance

Step 1: WACES selection and data collection

The assessment process follows the methodology described in Deliverable 3.1. Accordingly, as a first step, 24 WACES were selected, with each of the six ROps choosing four WACES relevant to their specific thematic focus. The assessment of the Questionnaires 1 and 2[2] resulted in a specific factsheet for each WACES, compiling all the available information. Each factsheet included both, a general information and a self-assessment of the six criteria defined in D 3.1.

After prefilling the factsheets, WACES holders were contacted and invited to provide feedback and/or participate in an interview. In total, 18 out of the 24 WACES interviews were conducted, which clarified open questions and placed special focus on barriers hindering or preventing WACES uptake. All interviews were recorded and transcribed. Based on the gathered information, the factsheets were revised and completed. Finally, the results were entered into summary tables – based on the factsheets –, which can be found in the different chapters or in the Annexes of this Deliverable.

Methodology to assess the barriers hindering or preventing WACES uptake

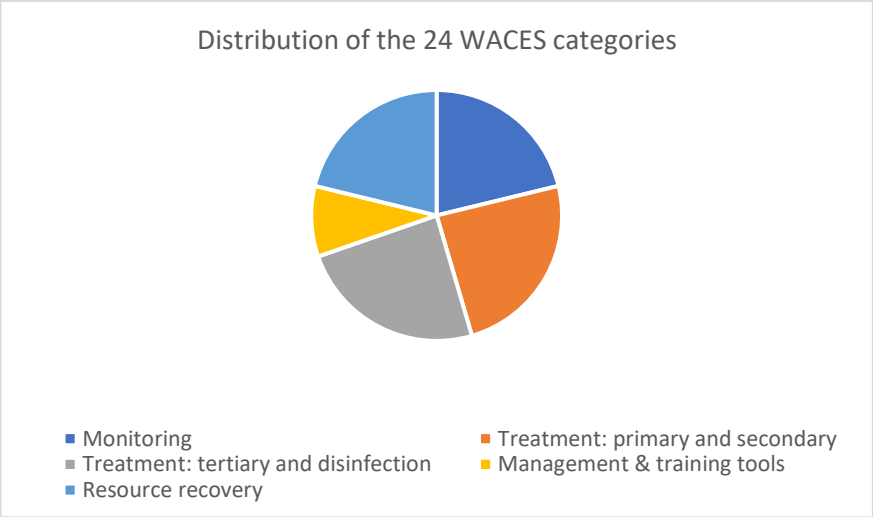
For the identification of the barriers a table listing was developed which is based on literature and experience from other projects. The development of the table additionally builds on the exchange with experts of the Alternative Water Resource for Climate Cluster, which connects the horizon projects MARCLAIMED, AWARD and RECREATE.

The WACES holders each separately filled out the barrier table with space for comments. If it was not returned before the interview and questions during the interview were used to gain further insights. The interview responses and pre-filled tables were subsequently compiled into an Excel file, with each barrier answer allocated to one of the predefined seven categories (Technological, Economic/Financial, Social, Political, Institutional, Regulatory/Legal, and Permitting). The goal was to enable a deeper analysis, using colour coding to highlight key barriers per topic and technology type (Monitoring; treatment: primary and secondary; treatment: tertiary and disinfection; management and training tools; resource recovery).

Step 2: Analysis of the WACES factsheets

In this deliverable, the analysis of the factsheets is presented in Chapter 3, where the six assessment criteria were evaluated and visualised in different formats. To ensure anonymity and prevent conclusions about the performance of individual technologies, the WACES were numbered from 1 to 24. However, to still enable meaningful analysis, the WACES were grouped into five different categories according to their objectives. The following provides a short description of those categories and in parentheses how many of the selected WACES apply to that category[3]:

[2] **Questionnaire 1** was part of the application process for WACES holder and contains mainly general information such as the technology type, short description, TRL, etc. (September 2024)
Questionnaire 2 was further developed to gather more specific information relevant for the climate risk assessment and barrier analysis. (January 2025)
[3] A WACES can apply to more than one category as in some cases a clear allocation was not possible.



1. **Monitoring** (Mon, 7): Monitoring devices usually measure water parameters, such as water quality (e.g., pH, contaminants like heavy metals and microplastics), flow rates, temperature, turbidity, and water pressure. Those devices support smart water management, because they can detect leaks, optimise treatment processes, track contaminants, and monitor sewer overflows.
2. **Treatment: primary and secondary** (TPS, 8): Primary solutions remove contaminants like sand, plastics, oily substances and organic solids. Secondary treatment solutions use microorganisms to break down dissolved organic matter. Both treatment processes generate solid waste or sludge that can be used for the production of biogas and/or energy. The produced sludge furthermore provides the basis for resource recovery either used directly or out of the ash after burning it.
3. **Treatment: tertiary and disinfection** (TTD, 8): Tertiary treatment removes remaining nutrients, fine particles and micropollutants using processes like advanced filtration, activated carbon or membrane technologies. Disinfection (e.g. UV, ozone, chlorination) then inactivates pathogens (e.g. bacteria, viruses), producing water that can be reuse (irrigation, industrial cooling, groundwater recharge, recreation) or is safe for environmental release.
4. **Management and training tools** (MTT, 3): Management tools integrate digital tools, such as the Internet of Things, artificial intelligence, and Geographic Information Systems allowing smart water monitoring and decision-making. They also facilitate collaboration between utilities, governments, industries, and communities. Training tools educate professionals, technicians, and decision-makers on circular water principles, advanced treatment technologies, resource recovery methods, public health and safety standards.
5. **Resource recovery** (RR, 7): Resource recovery extracts energy, nutrients, and materials from wastewater and related streams. Instead of being discarded, by-products are repurposed, for example energy from sludge or heat, nutrients (nitrogen, phosphorus), and salts or minerals from brine and desalination plants.

2.2 Assessment of the regional landscape for WACES implementation

Step 1: Data collection from the ROps

To analyse the policy landscape, enabling factors, and drivers within the ROps, a questionnaire was developed in a preparatory step - based on elements of Fidélis et al. (2020)[4]. In addition to the questionnaire, a barrier analysis table, consistent with that applied in the WACES assessment, was added. These two components provided the basis for assessing the enabling environment within each ROp. The ROps were then consulted to complete both instruments. To complement this process, a workshop was held during the BOOST-IN project team meeting in Bologna in June 2025. The workshop aimed to further advance the subsequent analysis examining WACES-drivers and enabling factors relevant to each ROp. Additional interviews with local stakeholders (including representatives of local authorities, companies, and experts) provided valuable perspectives on potential barriers and the policy landscape, adding context-specific insights into implementation conditions and challenges.

Step 2: Assessment of the ROp policy landscape, drivers, enabling factors and barriers

In this deliverable, the assessment of the ROps' policy landscape, drivers, enabling factors, and barriers is presented in Chapter 4, with findings analysed and partly also illustrated graphically.

3.0 Results of the WACES assessment

¡Error! No se encuentra el origen de la referencia. summarises the overall performance of the different WACES against the six assessment criteria. It provides an integrated view of how each WACES aligns with EU circular economy policies, identifies trade-offs, and evaluates their effectiveness, efficiency, uptake barriers, and climate resilience. The colour codes used in the table synthesise the findings related to each criterion, offering a clear visual representation of WACES performance (see table 2 for the colour code). In the following chapters, the structure of the summary table is explained in more detail, along with a step-by-step breakdown of the methodology used to complete it.

Table 1: Overview of the overall performance of the analysed WACES.

Category /WACES	*Mon*	*TPS*	*TTD*	*MTT*	*RR*	Policies addressed	Trade-offs	Effective-ness on the ground	Efficiency	Uptake	Climate resilience
1		x			x						
2	x			x							
3		x									
4				x							
5			x								
6					x						
7		x	x		x						
8		x									
9					x						
10					x						

[4] Fidélis, T., Abrantes, J., Cardoso, A., Miranda, A. C., Riazi, F., Teles, F., Roebeling, P., Lopes, M., & Capela, I. (2020): *D3.2: Policy and planning settings for the transition to Water Circular Economy – barriers and drivers in place; https://www.eu-project-o.eu/library/*

Category /WACES	*Mon*	*TPS*	*TTD*	*MTT*	*RR*	Policies addressed	Trade-offs	Effective-ness on the ground	Efficiency	Uptake	Climate resilience
11					x						
12					x						
13		x	x								
14			x								
15	x										
16	x										
17	x										
18		x	x								
19	x										
20	x										
21		x	x								
22	x										
23			x								
24		x	x	x							

Rating: The rating allows an assessment of the various categories, indicating how a WACES generally performs in that category. However, it is important to note that due to the substantial differences in content across individual criteria, the colour code provides a highly simplified yet justified overall evaluation.

Table 2: Legend depicting the colour coding for assessing the WACES contributions.

	Highly positive
	Moderately Positive
	Minor negative
	Clearly negative
	Strongly negative
	Not applicable

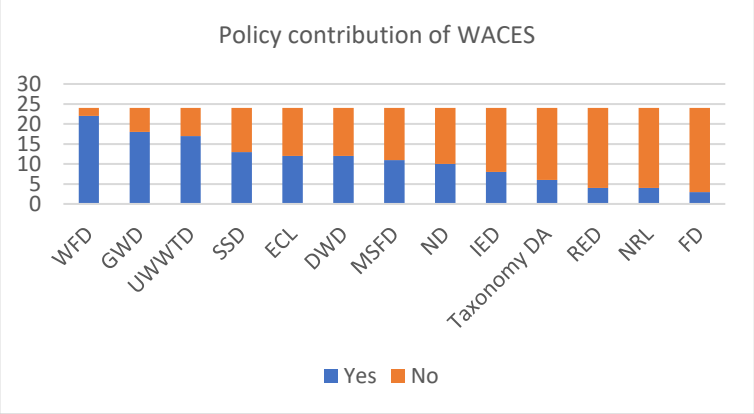
3.1 Policies addressed by WACES

The criterion "Policies addressed" responds to the question "Which EU policies potentially benefit from the WACES?". It evaluates the alignment between WACES and EU circular economy-related policy[5] objectives. The aim is to assess which EU policies potentially benefit most from the WACES and how/which WACES contribute to a wide spectrum of achieving those policies. This chapter examines how the 24 WACES potentially contribute to the 13 EU policies, compares the individual categories (Mon, TPS, TTD, MTT, RR), and evaluates their overall performance in terms of policy coverage. It should be noted that whether a WACES addresses a policy does not necessarily correlate with the level of its contribution. Therefore, a more nuanced assessment of performance is provided in Chapter 3.3.

The detailed results of the WACES analysis can be found in Annex I.

Figure 1 illustrates **how often the 24 selected WACES do address the 13 different EU policies[5], and which policies are more addressed than others**.

Figure 1: Do the WACES contribute to the different EU policies?



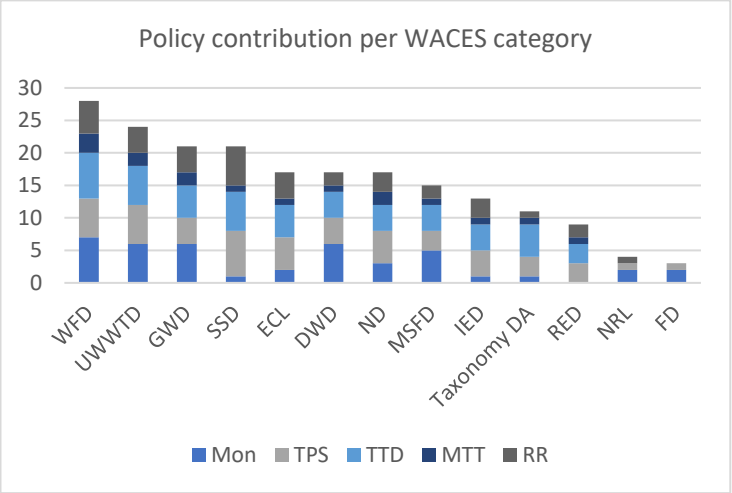
The results show that - according to the self-assessment of the WACES owners - most WACES address the Water Framework Directive (WFD) and its daughter directive, the Groundwater Directive (GWD). This result was expected, as the study focuses on solutions for the water circular economy, which in general somehow aim or indirectly contribute to improving water quality or quantity. Many WACES also address the Urban Wastewater Treatment Directive (UWWTD) and the Sewage Sludge Directive (SSD), reflecting the connection to wastewater treatment processes. Furthermore, positive effects can possibly apply to the targets of the European Climate Law (ECL), implying that several solutions tend to save energy or have lower greenhouse gas emissions compared to conventional technologies. Fewer WACES address the Drinking Water Directive (DWD) and the Marine Strategy Framework Directive (MSFD) than the WFD, which is caused by the wider scope of the WFD and partly due to the project internal scope definition, to what extent a positive impact can be achieved. A broad interpretation could mean that any improvement (e.g. less pollutant content released from a wastewater treatment plant (WWTP) in freshwater bodies regarding quality or quantity also benefits drinking water and marine ecosystems, while in a narrower scope, this is not the case. Within this analysis, it was on the assessor within the project team to decide, based on the provided information, how far a positive impact would be measurable. Regarding the Renewable Energy Directive (RED), only a few WACES address renewable energy generation, mainly through enhanced sludge treatment leading to higher biogas yields. The lowest numbers are observed for the Nature Restoration Law (NRL) and the Floods Directive (FD), reflecting the technical nature of most WACES. Only a small number are implemented outside facilities (e.g. WWTPs) or have characteristics comparable to nature-based solutions.

In the next analysis step, it was analysed **how often the WACES categories** (e.g. Mon, TPS) **address the 13 different EU policies and what the differences are**[6]. The results in Figure 2 show that:

[5] Water Framework Directive (WFD), Nitrates Directive (ND), Floods Directive (FD), Drinking Water Directive (DWD), Marine Strategy Framework Directive (MSFD), Groundwater Directive (GWD), Sewage Sludge Directive (SSD), Industrial Emissions Directive (IED), Urban Waste Water Treatment Directive (UWWTD), Renewable Energy Directive (RED), Nature Restoration Law (NRL), Taxonomy Climate and Environment Delegated Acts (Taxonomy DA), Climate Law (ECL)

[6] The total score the policy contributions exceed the number of the 24 WACES. This is because some of the WACES do belong to more than one category (e.g. Mon and TPS).

Figure 2: Policy addressed per WACES category.



Monitoring (Mon): The category performed the strongest in addressing the WFD targets and similar water-related directives, such as the GWD, DWD and MSFD. Most of the WACES in the monitoring category are used to measure water-related parameters, which serve to maintain water-related thresholds to ensure good water quality and compliance. Furthermore, they perform strongly regarding the UWWTD, improving the WWTP performance by allowing real-time data management.

Treatment: primary & secondary (TPS): There is no clear trend shown for TPS, as it performs relatively equally for most of the EU directives. This has to do with the broad spectrum that the TPS WACES operate. They improve outflow quality and quantity from a WWTP, which contributes to the water-related directives, but also improve processes that support energy and resource recovery.

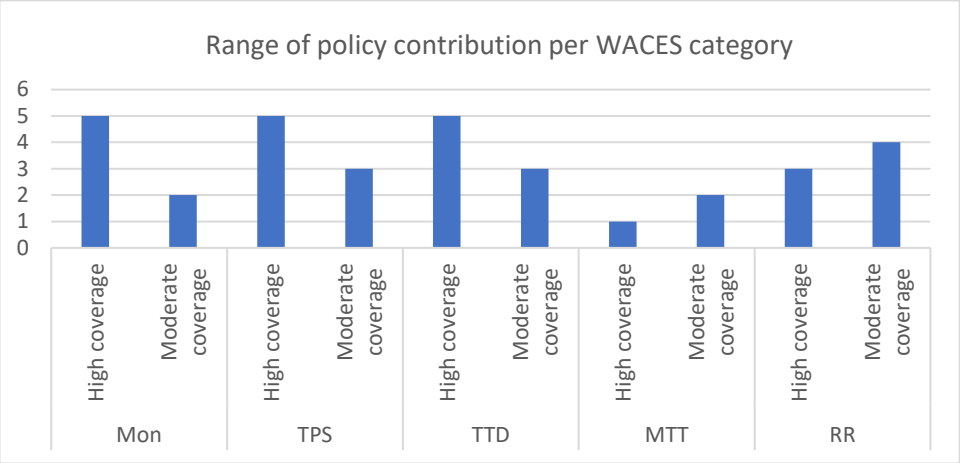
Treatment: tertiary & disinfection (TTD): Similar to TPS, no distinct performance trends were observed in this category, as many TTD WACES also fall into the TPS category. However, one difference that has been identified is that none of the WACES classified under TTD contribute to the NRL or the FD.

Management & training tools (MTT): Overall, MTT WACES show weak performance across all policies, except for the WFD. This is partly caused by the difficulty of clearly identifying the impact a MTT has on EU policies.

Resource recovery (RR): The WACES in this category show the strongest addressing towards the SSD. This is primarily because they reduce the volume of sludge generated and enhance the recovery of its valuable resources, such as nutrients (e.g. phosphorus) and energy (e.g. biogas). These solutions contribute to improving sludge treatment efficiency, facilitate safer agricultural use, and support the circular economy by turning “waste” into usable products. This category neither contributes to the NRL nor the FD and only minorly to the DWD, which makes sense, as implementation is mainly in WWTPs.

Figure 3 illustrates **the overall performance of the different WACES categories in terms of policy coverage**. Ten out of 24 WACES show high coverage (more than five EU policies addressed) and 14 show moderate coverage (less than five EU policies addressed). The results indicate that Mon, TPS and TTD include many WACES with high coverage across a wide range of EU policies. For example, monitoring has a wide range of applications, as it can be used to measure water quality and quantity in surface water bodies as well as within a WWTP. TPS and TTD WACES are more location-specific, typically implemented within WWTPs, but still address a broad scope of policies with their capabilities of wastewater treatment. By contrast, RR WACES tend to be more specialised in their field of implementation and, in some cases, have no direct influence on the water cycle – excluding many of the selected EU policies. MTT also show a trend towards moderate coverage, as their contributions are often too specific or cannot be clearly identified.

Figure 3: Overall performance of the WACES regarding their contribution to EU policies.



3.2 Trade-offs, indicating potential policy conflicts

This section explores and analyses potential conflicts between WACES implementation and the selected EU policy objectives, highlighting potential trade-offs that could limit WACES benefits. While the previous section (policies addressed) highlights potential positive WACES contributions to policy goals, this chapter analyses potential conflicts, referring to the question: "What are the potential trade-offs of WACES?"

The only trade-offs identified and confirmed through the interviews conducted with the WACES holders concerned the Industrial Emissions Directive (IED) and the ECL (see Annex II for details). These applied only to technologies related to resource recovery. This can be explained by the fact that recovering resources from sewage sludge or ash requires additional energy and therefore produces further greenhouse gas emission – if it does not originate from renewable sources. However, a detailed Life Cycle Assessment (LCA) would be needed to compare the recovered fertilisers with conventional fertilisers. In such case, the production of conventional fertilisers, which does not take place in the WWTP, is also energy-intensive – expanding the LCA to a wider Scope 3 scenario, which makes a comparison to recovered fertilisers more complicated. A similar picture emerges when looking at the TPS and TTD solutions. The assessment determined whether the WACES performed better compared to existing wastewater treatment technologies, rather than assuming no technology had been implemented beforehand. This again highlights the difficulty of comparability due to a lack of data and the variability of efficiency (e.g. variability of wastewater parameters, etc.) of a wastewater technology. WACES assigned to Mon and MTT did not involve trade-offs, likely due to their nature. Monitoring technologies are often add-ons to existing processes, rather than replacements with negligible energy consumption. This means they do not cause trade-offs between one policy objective and another but instead improve the overall WACES application.

Every interviewee was asked about the potential trade-offs, and most of them were nevertheless able to credibly argue that their WACES represented an immediate improvement of the status quo. However, these results need to be considered with caution since the interviews were conducted only with the WACES holders and miss additional expert input. Presuming a biased context, it was difficult to determine trade-offs, particularly as each provider would underline positive innovation aspects rather than stating negative impacts on policy targets. Lacking data also made it difficult to precisely compare conflicting WACES contributions.

3.3 Assessing WACES contributions to circular economy objectives (Effectiveness on the ground)

The "Effectiveness on the ground" criterion responds to the question "Are WACES significantly contributing to EU policies?". It assesses the extent to which the WACES achieve their intended objectives related to EU policy goals. The evaluation helps determine whether WACES are driving meaningful policy impact on the ground across different locations and implementation scales.

The effectiveness assessment builds on the relevance criteria assessment (see chapter 3.1 Policies Addressed), which already identifies the relation between the WACES and the corresponding circular economy EU policies. Now, in this chapter, the goal was to investigate more deeply how the WACES can positively contribute to the EU directive targets, by analysing them more qualitatively. The summarised results can be found below, and a more quantitative analysis providing an overall overview in Annex III.

Monitoring

Monitoring technologies support the WFD and the GWD by detecting pollutants, nutrients and microbial contamination in surface and groundwater bodies, enabling the assessment of ecological and chemical status and compliance with good status targets. Furthermore, the examined WACES support real-time monitoring, allowing quick action in case of a change in water quality (2, 15, 16, 17, 19, 20, 22). In terms of health protection, several monitoring technologies directly support the DWD by enabling real-time detection of microbial contamination, such as *E. coli* (17, 19), chemical pollutants like heavy metals (contributing to IED), nutrients (contributing to ND) (20) or other hazardous substances (2, 22). Furthermore, monitoring technologies can support the MSFD, especially when it comes to safeguarding coastal areas and early warning systems (e.g. if high *E. coli* values are close to swimming areas). Contributions to the targets of the UWWTD emerge where monitoring optimises wastewater streams and process control (22). Monitoring technologies can further support safer water reuse for agriculture and non-potable urban applications, reducing pathogen risks (19, 22). In addition, some monitoring technologies also have the potential to strengthen risk management under the FD as they support flood detection but also allow quick water analysis after a hazardous event (16, 20). Moreover, monitoring technologies can also support climate adaptation (contributing to the ECL) in agriculture through precision irrigation systems that prevent nutrient leaching and over-abstraction (16). However, a monitoring technology only delivers data and does not directly contribute to any improvement of the water cycle. A significant contribution towards the targets of an EU directive was only achieved for the DWD. Real-time monitoring of the potable water sector allows fast reaction, which is key to securing human health.

Treatment: primary & secondary

The TPS WACES have the strongest impact on the UWWTD and the WFD, reflecting the fundamental role of the first stages in a WWTP. Pre-treatment and screening steps reduce suspended solids and industrial pollutant loads through filtration. Fine screening and particulate reduction improve effluent quality and thereby support UWWTD performance and the WFD (as well as its daughter directive, the GWD) chemical status objectives (1, 7, 8, 13, 18, 21). However, the support to the WFD is mainly indirect through lower discharge rates of phosphorus and nitrogen pollutants. Equally, the TPS also mainly support the DWD indirectly, as lower potable water treatment is necessary if the water abstraction points already contain lower pollution. A concrete example is fine screening used as pre-treatment to cut particulate emissions and improve effluent quality. This furthermore improves biogas production, adding an operational co-benefit and contributions to the RED (1). Another TPS (8) enhances water storage infrastructure and contributes to the FD by limiting the flood risks and improving resilience. Furthermore, its nature-based solution, like structure, positively impacts the NRL, showing how an "industrial" nature-based solution can effectively contribute to different directives.

Treatment: tertiary & disinfection

Most of the TTD WACES belong to the TPS, meaning they enable higher levels of purification, including nitrate removal, micropollutant degradation, heavy metal reduction and pathogen control (5, 7, 13, 14, 18, 21, 23, 24). This explains why they perform strongest regarding the UWWTD and the WFD. For example, advanced oxidation (O_3/H_2O_2) can degrade persistent organic pollutants and pathogens while consolidating multiple processes into one reactor, reducing both energy demand and carbon footprint, which contributes to different directives (13). The DWD is addressed in a wider scope when advanced systems provide nitrate and pesticide removal or desalination for drinking water purposes. Cleaning the water from heavy metals can facilitate the direct water reuse in agriculture, and with further treatment, the water can be used for urban non-potable applications (21, 24, 7). Energy-efficient disinfection, such as UV-LED, supports the RED by lowering the energy use and indirectly contributes to the ECL due to lower emissions from less energy consumption.

Management & training tools

MTTs do not directly remove pollutants, but they are essential for ensuring compliance with the examined directives and their WACES are strongly linked to monitoring. They support fulfilling the WFD and other strongly water-related directives, such as the GWD, MSFD and DWD by detecting different pollutants, enabling the assessment of the water status (in coordination with monitoring technologies), and preparing the data that allows effective processing and interpretation (2, 4, 24). While their contributions to the other EU directives are mainly indirect, they still provide the database needed to demonstrate performance and guide management decisions. In addition to process improvements that save resources, MTT also help raise awareness among users, who benefit from cost savings generated by more efficient and better-informed operations.

Resource recovery

RR technologies support the close nutrient loops and transform wastewater – in particular, its solids or sludge – into a source of valuable materials. Their strongest contributions are made to the UWWTD, by improving treatment plant efficiency, which can lead to reduced pollution discharges (1, 7, 9, 10, 11, 12). An example is the struvite recovery, which produces a "slow-release fertiliser" (11), reducing phosphorus and nitrogen leaching caused by rain – positively contributing to the GWD and ND targets. Furthermore, it has been identified that RR WACES can support the SSD targets through better sludge management, reducing the amount of sludge that is dumped on landfills or burned (1, 9, 10, 11, 12). Additionally, the fertiliser produced from sludge has a lower heavy metal content compared to conventional fertilisers, as stated in different interviews. However, regarding the content of microplastics and other hazardous substances, no clear results have been identified (9). Moreover, the WFD and other water-related directive targets indirectly benefit from reduced pollution discharge from WWTP. The IED is addressed by lower process emissions (1, 11, 12), as, for example, the high-efficiency ammonium recovery (>95%) of one of the WACES (12) leads to a 15-30% N_2O reduction. Resource recovery also refers to an improvement of the biogas output from the sludge treatment, which leads to a higher energy output – contributing to the RED targets.

3.4 Efficiency of WACES

When assessing WACES Efficiency, no information was provided on this topic. An alternative approach using the data from the LCA to be carried out in Task 1.5 of the BOOST-IN project is not yet ready. In the case that meaningful results will be generated, this Deliverable will be revised at a later project stage.

3.5 Assessing WACES Uptake by identifying implementation barriers

The "uptake" assessment focuses on identifying and evaluating relevant barriers regarding implementation and uptake. The criterion responds to the question: "Which barriers hinder WACES

uptake?" The goal is to understand what barriers, limit effective WACES implementation and to determine their significance. Overall, 18 out of 24 WACES provided their barriers, enabling analysis. The results are summarised in Table 3 which provides an overview of the barriers identified, while Table 4 describes the colour coding of barrier severity.

Table 3: Severity of the barrier categories by each of the WACES.

Barrier/WACES	Type					Technical	Economic/ Financial	Social	Politics	Institutional	Regulatory/ Legal	Permitting
	Mon	*TPS*	*TTD*	*MTT*	*RR*							
2	x			x								
15	x											
16	x											
17	x											
19	x											
20	x											
22	x											
1		x			x							
3		x										
7		x	x		x							
8		x										
13		x	x									
18		x	x									
21		x	x									
24		x	x	x								
5			x									
14			x									
23			x									
4				x								
9					x							
10					x							
11					x							
12					x							
6					x							

Table 4: Description of barrier colour coding.

Significant barriers exist that cannot be addressed through modifications, rendering the solution unfeasible.	Significant
Significant barriers are present but can be overcome with substantial modifications to design, process, or resources.	Moderate
Barriers are manageable and can be addressed with minor adjustments, requiring relatively low effort and cost.	Minor
No barriers have been faced.	No barriers

The barriers are summarised according to the categories Mon, TPS, TTD, MTT and RR. The WACES allocated solely to the MTT category did not provide any input, while all other WACES in this category are also assigned to at least one additional technology. Consequently, MTT is not discussed separately but considered within the other categories.

Monitoring technologies mainly face technical barriers, though these are mostly minor, with one case classified as moderate. Further moderate barriers arise from social, institutional, and permitting aspects, while economic, political, and especially regulatory/legal barriers were classified as significant.

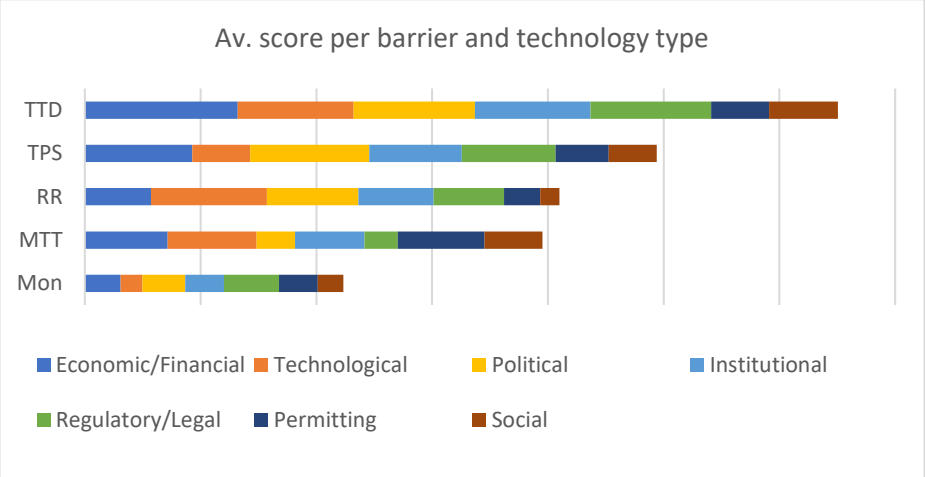
Primary and secondary treatment technologies encounter significant barriers in political and institutional terms, with economic/financial and regulatory/legal aspects representing the most prominent moderate barriers. Notably, five out of seven WACES in this category are also classified as tertiary and disinfection technologies.

Tertiary and disinfection technologies are primarily affected by significant institutional and regulatory/legal barriers, while economic/financial and political aspects are most often seen as moderate. Technological barriers are generally minor.

Resource recovery technologies face significant barriers related to politics, institutional aspects, and permitting. Regulatory/legal and economic/financial barriers are mainly classified as moderate, whereas technical, social, and permitting aspects are mostly seen as minor.

When comparing the barrier levels across technology types (Figure 4), it becomes clear that TTD and TPS face overall the most barriers. RR and MTT follow, while Mon is least affected. A general explanation could be that the implementation of TTD and TPS technologies usually involve more complex processes, often requiring substantial modifications on-site and the involvement of various stakeholders. In contrast, MTT and Mon typically involve smaller adjustments, which are less likely to be noticed externally, for instance from political or social perspectives.

Figure 4: Overview of the average score per barrier and technology type.[7]



Across all technology types, regulatory/legal are the most prominent barriers, significantly or moderately hampering their implementation. Politics, as well as economic/financial, also pose significant or moderate barriers to various WACES types. Institutional limitations were also identified as significant

[7] The graph is based on the weighted average of each of the barrier categories. This method was used because each barrier category consists of a different number of subcategories. Therefore, using the overall score would distort the results.

barriers across several WACES. Despite being categorised as a significant barrier once, permitting procedures pose moderate or minor barriers, if any. Overall, social and permitting were the least prominent barriers across the WACES technology types.

After this overall analysis, the next section describes the identified barriers in more detail. In parentheses, the solution number and technology type (e.g. Mon, 1) are provided to clarify which solutions each barrier refers to. It should also be noted that the questions are based on interviews and therefore reflect the views of the respective WACES holders. As a result, findings have limited transferability within a technology type or across other types. Nevertheless, the detailed analysis offers a deeper understanding of the challenges that different WACES holders face when it comes to uptake.

Technological

When analysing the technological barriers regarding the **lack of (technological) availability or feasibility**, no significant barriers were identified, but barriers occur when installing WACES in remote (agricultural) areas, requiring additional measures before installation (TTD, 5) and sufficient space (TPS, 8). In general, the installation of a WACES to be integrated in existing infrastructure can be challenging, increasing the need for individual adjustments (TPS, TTD, 13; Mon, 22). Larger-scale solutions may depend on strategic planning and investment, for example within the WFD River Basin Management Plan Programmes of Measures. Also, unsatisfactory water quality or nutrient composition in the wastewater source, can cause either additional water treatment or necessary infrastructure to ensure efficient WACES operation (TTD, 5). For instance, an identified barrier was that industrial wastewater is better suited for resource recovery as it is higher concentrated in substances than domestic water, allowing larger amounts of energy to be obtained compared to communal WWTP (TPS, TTD, RR, 7). Furthermore, WACES especially those that concern disinfection need market clear targeted quality requirements in order to justify the uptake of additional and more complex technology (TPS, TTD, MTT, 24)

In terms of **lacking consistency and certification**, moderate barriers were mentioned concerning mainly Mon WACES, which call for clearer certification systems to enable broader uptake (Mon, 19). For example, Environmental Technology Verification schemes typically certify individual technologies, which makes it difficult for legislation to formulate generic, performance-based rules. By contrast, standardised laboratory methods – usually aligned with ISO standards – facilitate clearer definition of requirements (Mon, 17). Minor barriers arise when a WACES lacks sufficient technological robustness, as even well-designed systems may require careful calibration and sample-handling procedures that depend on standardised methods and disciplined operation (Mon, 15).

In terms of **training and capacity building needs** of WACES operators, technologies of higher complexity compared to conventional solutions require more planning efforts in engineering and safety measures (TPS, TTD, MTT, 24), which are knowledge gaps that require long term efforts (TPS, RR, 1). For example, the recovered products from WACES can involve dangerous goods, such as biogas, requiring additional expertise compared to conventional aerobic processes (TPS, TTD, MTT, 24). Therefore, trained staff is needed (Mon, 15). This demand for specific expertise also explains why operators often prefer conventional systems, as they are more familiar and perceived as easier to manage (TPS, RR, 1).

A barrier when investigating **remaining uncertainty** was raised doubts from plant operators that concern the long-term viability of materials or the technologies that are used by the WACES due to limited comparability of projects (TPS, TTD, RR, 7). Furthermore, lacking assessments of certain pollutants (e.g. micro plastics) (RR, 11; TTD, 23) leading to uncertain performances under different national regulations (TPS, TTD, 13).

Economic/Finance

The need for **financial aid** was one of the most significant barriers. A recurring issue are the high upfront investment costs, which is also partly hampered due to a lack of risk capital in Europe (RR,9; TTD, 14). The

lack of sufficient investment capital is especially an issue when a WACES is implemented by small-scale operators or smaller municipalities (Mon, 15). Without the access to EU funding the implementation was financially impossible (TPS, 8). Non-profit developers, in particular, face structural disadvantages, as their financial models reduce attractiveness for investors and increase dependence on grants (TTD, 23).

A reason for the need for financial aid coming especially from public funding is the **low financial attractiveness**, which was reported from many WACES. High capital investment costs partly caused by the need to develop WACES implementation from scratch compared to existing technologies, reduce attractiveness (TPS, TTD, MTT, 7). Long development timelines (RR, 9), long payback periods, and uncertain returns discourage investment (TPS, TTD, 13; TTD, 14). The profitability of recovered resources with a margin of about 50% makes it challenging to self-sustain (RR, 11). Recovered products are sold on small and underdeveloped markets – also due to small amounts of produced products, which keeps the prices high (about 20-30% more than conventional alternatives) and limits cost recovery (Mon, 17; TPS, TTD, 21). Where no legal obligations exist, financial incentives remain weak (TTD, 23). The low financial attractiveness is also supported by economic uncertainty due to the mentioned small markets. The dynamics of these markets are highly dependent on local initiative and the high upfront costs create the need for financial revenue – especially important for private investors – which makes investments unattractive (TPS, TTD, 21; TPS, TTD, MTT, 24).

Another barrier linked to financial attractiveness is the **lack of market demand**. This is the case if cheaper alternatives are on the market (TTD, 5), which for example leads to resistance of farmers who are unwilling to pay a higher price for recovered fertilisers (RR, 9) and prioritise economic issues over potential environmental benefits (TPS, TTD, 13).

Barriers due to the lack of a **cost-efficient price system** were identified when market valuation mechanisms made it difficult to establish fair and transparent pricing (TPS, 13). For example, if wastewater fees are not transferred to private operators a structural disadvantage is created (RR, 9). The higher price of reclaimed water compared to potable sources further show a systemic issue regarding cost-recovery (TPS, TTD 21).

Lacking market demand was classified as a significant or minor barrier. Treated wastewater is more expensive per cubic metre than potable groundwater, and water use from rivers is also cheaper than reusing treated (domestic) wastewater, making it a significant barrier. Yet, a growing and high future demand for treated water due to water shortage could address the issue. Despite the proven effectiveness of WACES, water utilities are still hesitant about their associated financial risks (minor barrier). Regarding Mon WACES, operators comply only with minimum legal requirements, not seeing the benefits of real-time monitoring, reducing demand for additional monitoring technologies (Mon, 17)

Social

Concerns about **potential environmental or social impacts,** including potential consumer rejection of products irrigated with treated wastewater due to safety perceptions, causes farmers to turn away from its usage (TTD, 14; TPS, TTD, 13). Furthermore, **economic concerns** in connection to the social aspect was raised related to the negative impact of poor water quality on tourism (Mon, 17). The **spread of misinformation** was mentioned by several WACES as an issue, which causes mistrust of stakeholders and fears for example about illnesses caused by treated wastewater. This and **inadequate community engagement** can cause conflicts with stakeholders.

Political

Communication challenges linked to **political knowledge** barriers arise when customers follow political recommendations rather than the latest technological possibilities (TTD, 5). This becomes problematic when politicians lack sufficient knowledge of the technical methods required to ensure good water quality (Mon, 17). Politicians still focus on traditional designs, potentially due to a lack of trust in the

solution's functionality (TPS, RR, 1; Mon, 19). This connects also with a **poor understanding of stakeholder needs** from a political side, leading to misleading strategic decisions (TPS, TTD, 21).

Barriers due to **rigid political structures** concern governance structures in general but also the national implementation of EU directives, which varies considerably (TPS, TTD, 13), and while EU-level directives such as the WFD were sometimes viewed as beneficial, their translation into national contexts creates uneven conditions for WACES uptake (TPS, TTD, RR, 24).

Another barrier pertains to the **lack of long-term planning,** which poses a challenge especially regarding public entities that need to follow strict public procurement rules in the water sector. This delays the market entry of new solutions (TPS, TTD, RR, 7). Furthermore, the lack of political targets and budgetary uncertainty, alongside a general more fragile political environment limit the possibility for future planning (TPS, TTD, 21; Mon, 22).

Institutional

A **lack of coordination and unclear responsibilities** were identified in different WACES (TPS, TTD, RR, 7; Mon 19), which can be caused by decentralised structures and overlapping jurisdiction, particularly in federal systems (TTD, 23). This leads to authorities that do not see the full picture, as they work on their own areas (e.g. energy, water, etc.) not connecting them in an interdisciplinary way (TPS, TTD, RR, 7). The lack of connection does not only concern the sectors, but also the different government levels (Mon, 19).

Barrier spotlight: Public procurement (TPS, TTD, RR, 7)

Public procurement rules often hinder the uptake of innovative WACES. In the water treatment sector, where most facilities are owned by municipalities or governments, strict tendering laws require at least three comparable offers. While this ensures fairness, it disadvantages unique technologies, as equivalent alternatives may not exist. As a result, innovative solutions are difficult to evaluate alongside conventional options, slowing their market entry and limiting opportunities for sustainable system improvements.

Limited support from authorities causes significant barriers regarding WACES uptake flexibility. This includes the fact that certain EU-level regulations demanding standardised products with fixed outputs, restricting and undermining the flexibility (TTD, 5). Some solution providers also call for a shift from prescribing specific solutions to result-oriented tenders, leaving little room for innovation (TPS, TTD, RR, 24). Furthermore, a shift in the mindset of authorities towards accepting water reuse and adjusting the laws to support water reuse, perhaps even requiring it where applicable (RR, 16). There is also a lack of political support to cover wastewater treatment costs via wastewater fees (RR, 9).

Regulatory/Legal

The **lack of harmonised standards and inflexible policy frameworks** was repeatedly mentioned as a barrier for WACES uptake, mainly due to differences between EU countries. This particularly affects resource recovery solutions, where the end-of-waste status or the conditions for resource use vary nationally (TPS, RR, 1). Differences or missing standards for microbial detection methods further hinder comparability across systems (Mon, 15). In several cases, legislation only permits laboratory measurements while online methods are not accepted, and the process of implementing regulatory changes can take decades (Mon, 17). Another issue relates to confusing legislation on the reuse of rain- and stormwater (Mon, 19). The lack of an integrated approach to the water cycle remains problematic, since stakeholders frequently concentrate on their own segments rather than pursuing system-wide solutions (TPS, TTD, RR, 7). The DWD leaves room for interpretation, with some authorities prohibiting permanent disinfection despite this not being explicitly stated. This creates inconsistent application

across jurisdictions and highlights a conflict between reducing chemical use and ensuring microbial safety (TTD, 5).

Lack of regulatory clarity present an additional barrier. This includes unresolved questions of ownership concerning treated wastewater, energy production, and resource recovery (TPS, TTD, RR, 7). The legal classification of recovered materials is frequently undefined (TPS, RR, 1). New regulations, such as the Spanish law on water reuse (RD 1085/2024), can further delay project approvals, as actors tend to wait for implementation before proceeding (TTD, 14). In some cases, online measurements are not explicitly prohibited but are still not officially recognised, leaving only laboratory results valid for compliance (Mon, 17). Moreover, the ongoing revision of the Urban Wastewater Treatment Directive fails to include binding measures on microplastics, creating further uncertainty (TTD, 23).

Permitting

Complex and lengthy permitting processes delay WACES uptake, despite interest from stakeholders, such as agriculture for their implementation (TTD, 14; Mon, 22). Regarding WACES that recover resources, there was a significant bottleneck mentioned across the EU, concerning the fact that there are only a few organisations that are authorised to certify fertiliser under the EU Fertilizing Product Regulation, taking up to one and a half years to be authorised. In addition, certification and validation procedures outside the EU are highly time-consuming and costly, as local requirements often override ISO certification (Mon, 22).

3.6 Climate resilience – WACES' ability to withstand climate-related risks

Climate resilience addresses the question, "How climate-proof are WACES?" by assessing their long-term ability to withstand climate-related risks and continue delivering benefits under changing environmental conditions. This involves evaluating vulnerabilities to extreme weather events, floods, sea level rise, droughts, and other hazards to ensure their functionality and sustainability. Furthermore, this criterion reflects the extent to which the net benefits of the WACES intervention continue or are likely to continue, within the financial, economic, social, environmental and institutional capacities of the systems needed to sustain the net benefits over time.

The following section presents summarises information from the second questionnaire (self-reported sensitivity by WACES holders) and from the Climate Risk Assessments (CRA). For these assessments, the case study locations indicated by the respondents were used to examine their vulnerability to various hazards. The analysis followed the methodology described in detail in Deliverable D3.1 and the EU climate proofing guidance. Differences in the colour coding reflect the varying levels of detail in the assessments. Overall, ten out of the 24 selected WACES reported sensitivity to climate hazards, and nine of these provided an implementation location that enabled a full CRA.

Table 5 summarises WACES sensitivity to climate hazards as reported by the providers. High sensitivity was stated towards flooding, as well as ice and snow, followed by droughts & water scarcity and extreme temperatures. Medium sensitivity was most often identified towards extreme temperatures, followed by ice and snow. WACES also identified medium sensitivity to droughts & water scarcity, and least often to flooding and storms. Overall, sensitivity to storms was of least concern.

Table 5: Sensitivity of the WACES to the different hazards.

Sensitivity/ WACES Nr.	Type	Extreme temperature	Droughts & water	Flooding	Ice and snow	Storm
1	TPS					
7	TPS, TTD					
8	TPS					
13	TPS, TTD					
14	TTD					
16	Mon					
17	Mon					
21	TPS, TTD					
22	Mon					
24	TPS, TTD, MTT					

Table 6: Description of the climate sensitivity colour coding.

High sensitivity: The climate hazard significantly impacts assets, processes, inputs, outputs, and/or transport links.	
Medium sensitivity: The climate hazard moderately impacts assets, processes, inputs, outputs, and/or transport links, potentially causing minor disruptions.	
Low sensitivity: The climate hazard has a minimal or no impact on assets, processes, inputs, outputs, and/or transport links.	

Table 7 summarises the vulnerability of WACES based on their implemented locations. Two WACES located in Belgium and France face an extreme risk towards storms. Flooding (Belgium), and droughts & water scarcity (France) each also pose an extreme risk for one WACES. For six WACES, a high risk towards extreme temperatures was identified in all countries except for the Netherlands and Belgium.

Table 7: Vulnerability of the WACES based on their implemented location.

Vulnerability/ WACES Nr.	Type	Case study country	Extreme temperature	Droughts & water scarcity	Flooding	Ice and snow	Storm
1	TPS	Netherlands					
7	TPS, TTD	Spain					
8	TPS	Belgium					
13	TPS, TTD	Italy					
14	TTD	Spain					
16	Mon	Greek					
17	Mon	Belgium					
21	TPS, TTD	France					
24	TPS, TTD, MTT	Spain					

Table 8: Description of the climate vulnerability colour coding.

Extreme risk: The WACES is exposed to severe natural disasters at its location, leading to potentially significant disruptions. Limited adaptation measures are in place, and limited adaptation can be done, raising concerns about economic viability and long-term sustainability.	
High risk: The WACES faces considerable risks from natural hazards, which could result in notable challenges. While some adaptation measures exist, their effectiveness may be limited, and further adaptation options are constrained, potentially affecting functionality and performance.	
Medium risk: The WACES is moderately affected by natural hazards. Existing adaptation measures can manage these risks to a degree, but the scope for further adaptation may be limited, making additional measures necessary to ensure resilience and optimal operation.	
Low risk: The WACES is minimally affected by natural hazards. Existing adaptation measures are adequate, with limited need or scope for additional adaptation, ensuring no significant risk to functionality, economic viability, or long-term sustainability.	

Comparing sensitivity and vulnerability highlights the differences between the WACES sensitivity and the overall vulnerability of the facility in which the WACES is implemented. In many cases, WACES owners did not report any sensitivity to a particular hazard, whereas the results of the vulnerability analysis indicate otherwise. Such discrepancies can reduce the overall performance of the WACES. For example, a WACES itself may not be vulnerable to flooding, yet if the WWTP is located next to a river with a notable flood risk, the entire plant could be forced to shut down during a flood event. However, the tables also show cases where the opposite applies. Within all categories WACES have been identified that are sensitive to ice and snow, but none of the case study locations are situated in areas at risk from these hazards. Furthermore, only a few hazards show a sensitivity towards high temperatures. However, the vulnerability assessment also considers the personnel on site who are exposed to heat while operating the facility, which also includes keeping the implemented WACES running. This may necessitate additional measures, which could be considered in future planning.

4.0 Regional policy context analysis

This chapter examines the regional framework conditions for WACES uptake in the six ROps based on the information they submitted. At first laws and strategies relevant to water reuse and circular economy are

reviewed and it is assessed whether they refer to WACES and promote circular economy measures. In a next step, the barriers reported by the ROps are assessed, followed by an overview of potential drivers and enabling factors that can facilitate WACES uptake. Overall, the goal is to provide a broad picture of the policy and governance landscape shaping implementation across the ROps.

4.1 ROp circular economy related policies

Based on the information provided by BOOST-IN ROp leaders, WACES-relevant regional policy instruments (laws and strategies) aligned with each ROp's specific focus were identified[8]. The full list of submitted laws and strategies can be found in Annex IV.

In total, 35 national legal instruments were identified in the ROps. The most frequently submitted topic concerns water reuse, which appears in nine legal texts across the countries. Other relevant areas include general water legislation (four entries), laws concerning energy and climate (four entries), and fertiliser regulations (three entries). A number of acts also focus on wastewater, emission control, surface and groundwater protection, and drought-related water infrastructure.

Overview of legal instruments by country (number of laws identified):

- Germany (8): Focus on wastewater management, fertiliser regulation, and water quality standards.
- Bulgaria (7): Covers a broad range of topics, including water, waste, fertilisers, and energy.
- Italy (5): Mainly addresses water scarcity and water reuse.
- France (6): Focuses primarily on water reuse.
- Greece (3): Addresses water reuse and general water management.
- Spain (6): Includes reclaimed water and a regional water law (Andalusia).

In parallel, 14 national or regional strategies and plans were identified, providing an overview of how policy directions and planning efforts relate to water and circular economy themes.

Overview of strategy topics by country (number of strategies identified):

- Italy (5): Covers circular economy, water protection, investment planning, and river basin management (national and regional levels).
- Bulgaria (4): Focused on water sector development, circular economy, climate and energy, and river basin management.
- Greece (1): Addressed circular economy strategy and implementation.
- Spain (3): Covers river basin management and regional climate action.
- France (1): Addressed national water management and resource resilience.

The results show that all six countries have taken steps to address water and circular economy, either through binding legislation or through policy strategies. Therefore, the relative weight of certain topics or countries may appear over- or under-represented and therefore the overall picture should be interpreted with a degree of caution.

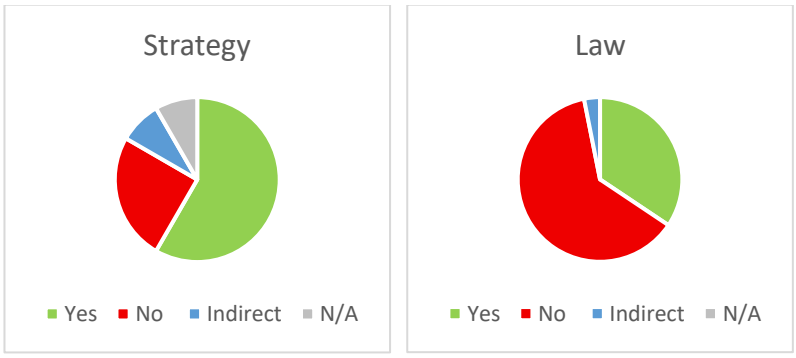
[8]Andalusia (ES): Municipal water reuse in agriculture; Peloponnese (EL): Industrial water and material reuse; Lower Saxony (DE): Nutrient and energy recovery; Bretagne & Pays de la Loire (FR): Indirect potable reuse; Emilia-Romagna (IT): Municipal water reuse in agriculture; Srednogorie (BG): Metal recovery from mining wastewater

4.2 ROp policy scoping results

Direct mention of WACES in law and strategies

The analysis (Figure 6) of the examined laws shows that the majority (20 out of 32) do not contain any direct references to WACES. Only 11 laws include a direct mention, while 1 law refers to it indirectly, which means it contributes positively to the enabling environment, although less than those with direct references. In contrast, most strategies (6 out of 12) do directly mention or address WACES. One strategy includes an indirect reference, while three do not mention it at all, and one is not applicable.

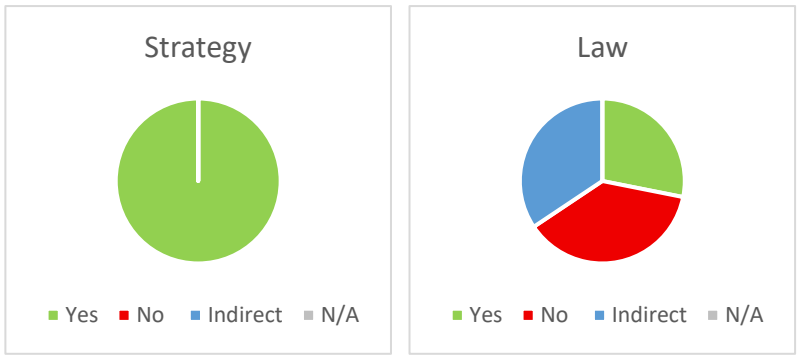
Figure 5: Overview if a strategy or a law directly or indirectly refers to a WACES.



Promotion of circular economy measures

When it comes to promoting measures (Figure 7), nine laws explicitly support circular economy actions, and 11 support them indirectly. However, 12 laws do not promote such measures at all. In strong contrast, all of the strategies analysed (12 out of 12) support the promotion of circular economy measures.

Figure 6: Overview if a strategy or a law promotes circular economy measures.



4.3 Analysis of WACES contribution to national laws and decrees

The following overview provides a short description of the main topics relevant to WACES in the analysed laws. It also includes examples from the selected national laws and highlights their connection to different EU directives.

Wastewater reuse

Several of the submitted national laws and decrees directly promote the reuse of treated wastewater, especially for agricultural irrigation, urban uses, and industrial processes. These frameworks define permitted reuse types, quality thresholds, risk management plans, and monitoring procedures. The frameworks align with or orientate on the EU regulation on minimum requirements for water.

Examples from the ROps:

- **Italy:** Regolamento sul Riuso Idrico (DM 185/2003) - Water reuse regulation
- **Greece:** Joint Ministerial Decision No. 145116/2011 - Water reuse regulation
- **France:** Décret 2023-835 - Water reuse regulation
- **Spain:** Real Decreto 1085/2024 - Water reuse regulation

Water in general

Several national frameworks govern the sustainable use and protection of water resources, typically in line with the WFD. These laws cover water abstraction and discharge permits, integrated basin planning, tariff systems, and public service obligations.

Examples from the ROps:

- **Bulgaria:** National water act
- **Greece:** Law 3199/2003 – Main WFD transposition
- **Germany:** Wasserhaushaltsgesetz (WHG) – Regulates surface and groundwater protection
- **Spain (regional):** Ley 9/2010 de Aguas de Andalucía – Regional law with reuse incentives
- **Italy**: Testo Unico Ambientale – Cross-sectoral water-energy-climate synergies

Energy and energy efficiency

National frameworks on energy efficiency and renewable support WACES through energy-saving measures and renewable integration in the water sector. These laws align with the EED and the RED.

Examples from the ROps:

- **Bulgaria**: Energy Efficiency Act;
  Energy from Renewable Resources Act – Biogas recovery from sludge

Fertiliser and nutrient recovery

Laws regulating fertilisers and nutrient recovery relate to the ND and the SSD. These frameworks support nutrient reuse and limit nitrate and phosphate pollution.

Examples from the ROps:

- **Germany**: AbfKlärV – Mandatory phosphorus recovery above defined thresholds, DüMV – End-of-waste criteria for fertilisers from recovered nutrients
- **Bulgaria**: Ordinance No 2/2000 – National law about nitrate and agricultural pollution

Circular economy and resource recovery

Several countries reference or implement actions aligned with the Circular Economy Action Plan. These laws promote reuse, efficiency, and recovery of water, nutrients, and energy across the water cycle.

Examples from the ROps:

- **Italy**: Strategia nazionale per l'economia circolare – National circular economy action plan
- **France**: Anti-waste law for a circular economy nce
- **Spain**: RD 1085/2024 – Regulation on water reuse and amending various royal decrees regulating water management

Drought management and infrastructure adaptation

Recent national legislation responds to increasing water scarcity and climate risks. These measures support water reuse, infrastructure adaptation, and long-term planning. They align with the EU Climate Adaptation Strategy and the EU Regulation on minimum requirements for water reuse.

Examples from the ROps:

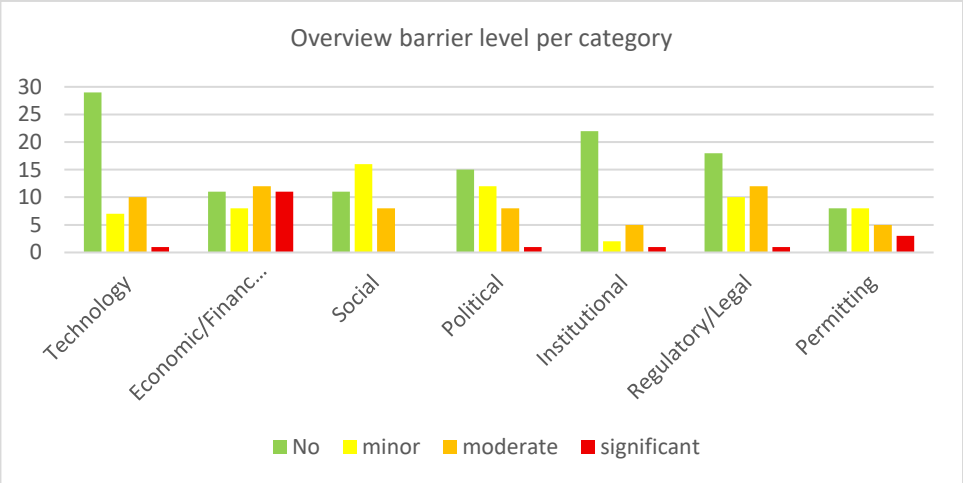
- **Italy:** Law 13 June 2023, n. 68 – Promotes reuse, monitoring, and infrastructure upgrades
  Decreto Siccità (April 2023) – Enables rainwater harvesting and fast-tracks projects

4.4 Identified barriers per ROp

The following section examines the ROp-specific barriers that may restrict or prevent the successful WACES implementation. All six ROps completed a list of barriers identical to the one used for the WACES assessment (section 3.5. of this report), offering a deeper insight into what hinders successful implementation.

Figure 8 presents the overall barrier scores, broken down by category. It shows the number of times each barrier was identified, classified as no barrier, minor barrier, moderate barrier or significant barrier. The results reveal that significant barriers are particularly dominant in the Economic/Financial category, followed by Permitting, although to a much lesser extent. Regarding moderate barriers, Economic/Financial and Regulatory/Legal stand out with the highest frequency, although all other categories also record multiple mentions. In the minor barrier category, Social is most prominent, with Political and Regulatory/Legal also showing comparatively high counts.

Figure 7: Overview barrier level in the different categories.



Since the number of subcategories varies between the main categories, it is not yet possible to draw firm conclusions about which category overall contains the most barriers. Therefore, the weighted means were calculated to allow better comparison (No=1; Minor=2; Moderate=3; Significant=4). Higher values indicate a greater likelihood of barriers, but results should be interpreted with caution given the ordinal scale.

Figure 9 depicts that the Economic/Financial category shows by far the highest barrier level, followed by permitting and social. The fewest barriers appear in the institutional category.

Figure 8: Weighted average score per category, revealing the category with the highest barrier level.

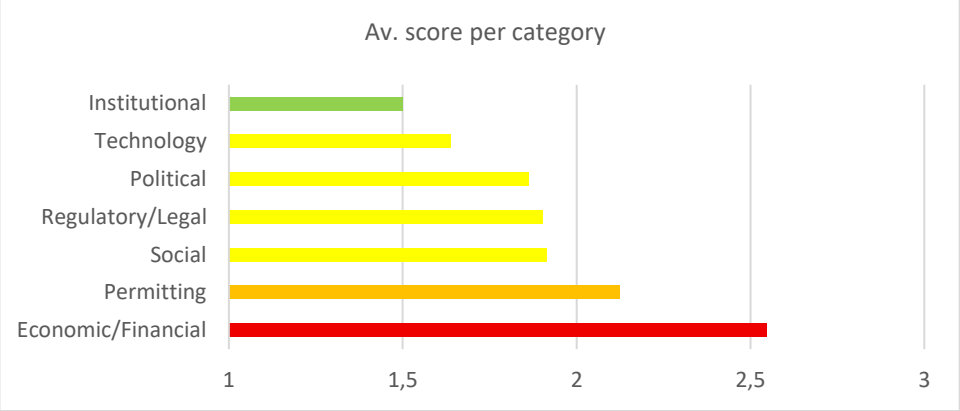
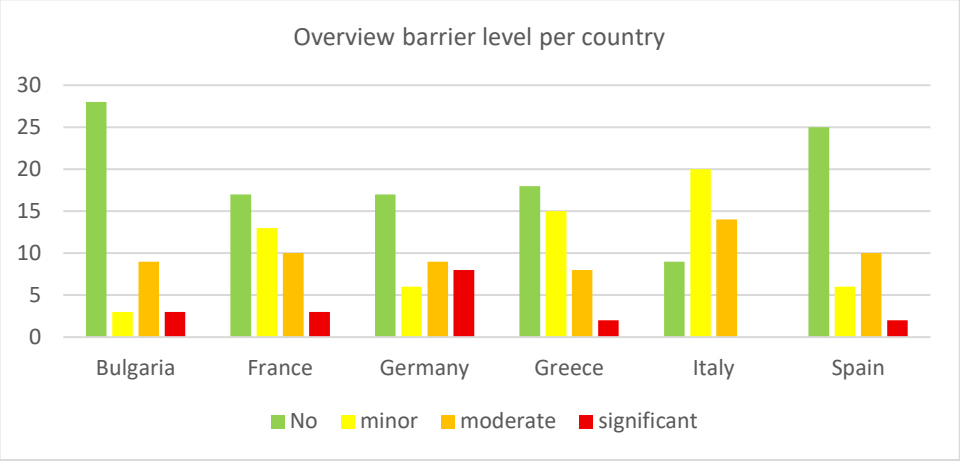


Figure 10 summarises the results submitted by each of the six ROps. All of the ROps face barriers at different levels. However, as each of the Rops have a different focus (e.g. agricultural or industrial reuse), they also face different challenges. Therefore, this figure should rather give a country specific overview than lead to a direct comparison among ROps.

Figure 9: Overview of the barrier level in the 6 ROps.



The following section, based on the barriers identified in Annex V, highlights those that pose the greatest challenges within the ROps. The focus is primarily on barriers classified as moderate or significant, which are described within their respective categories.

ROp-specific technical barriers

Availability and feasibility: These two barriers were only recognised by BG, where modern solutions for treating mining-related pollutants are scarce. New technologies are often not feasible due to space and infrastructure constraints in the mining sector, requiring high investment.

Infrastructure: Four of the ROps reported a minor or moderate barrier regarding a lack of infrastructure. In EL, many wastewater treatment plants lack tertiary treatment, and ES reported a lack of distribution systems for reuse, particularly in rural or agricultural areas. FR highlighted a lack of treatment and delivery infrastructure, especially before project planning. In DE, the logistics for fertiliser distribution remain challenging.

Training and capacity building: A lack of operator and farmer training is a major barrier in ES. In DE, some processes, such as ash-based systems, require specialised skills.

ROp-specific economic/financial barriers

Need for financial aid: Economic support is a major barrier across countries, with high initial investments for modern water treatment and reuse cited in BG and ES, requiring subsidies or EU co-financing (e.g., PERTE, CAP). In DE, low fertiliser market values hinder cost recovery. EL highlighted the need for funding in smaller municipalities, while IT raised uncertainty over who bears the cost of additional treatment.

Absence of standardised pricing: This barrier was mentioned by several countries as a moderate barrier. In DE, the low market value of unprocessed recovered nutrients and reliance on large-scale supply chains restrict viable business models. EL and FR noted the absence of consistent pricing mechanisms for reclaimed water.

Lack of research funding: The lack of funding for research was also mentioned several times as a moderate barrier. In DE, support for demo plants is declining, while further references under real conditions are needed to encourage uptake. EL and FR pointed to limited and sporadic national-level funding, despite opportunities through EU programmes such as Horizon Europe or LIFE. IT underlined that the additional treatment costs linked to reuse technologies make research and innovation funding essential.

Low financial attractiveness, market demand and high uncertainty: These have also been identified as major economic barriers. BG and ES reported long payback periods that reduce the economic viability of innovations. In DE, fertiliser values are too low to recover investment and operational costs, although synergies with wastewater treatment plant efficiency and gate fees for ash treatment provide some relief. In FR and EL, the low cost and relative abundance of water discourage reuse practices and hamper new projects. Also, high uncertainty regarding political support for water reuse projects hinders the provision of more incentives, as reported by DE and BG.

ROp-specific social barriers

Concerns about potential environmental or social impacts: In the social category, this barrier was reported most by several ROps. Public distrust in BG remains high regarding the safety and effectiveness of recycled water. In DE, farmers use recovered fertilisers when they are cheaper than conventional ones, but variability in nutrient composition creates reluctance despite generally high quality. In FR, restraints towards water circular economy projects resulting from perceptions that they reinforced damaging economic models, such as prioritising large-scale monoculture irrigation over support for independent farms. In ES, public and farmer perceptions of “dirty water” persist, with awareness campaigns and transparent monitoring supporting building trust.

Other barriers, like the spread of misinformation, economic concerns, and inadequate community engagement, were also reported sometimes. However, no specific information was delivered, and the barriers were mainly minor.

ROp-specific political barriers

Lack of circular economy framework: In BG, the absence of a national circular economy strategy in the water sector hinders initiatives. In DE, national wastewater law was set to boost phosphorus recovery from 2032, but strict requirements and waste regulations still pose obstacles. In EL, water reuse is only partially integrated into mainstream strategies.

Lack of long-term planning: This issue was reported across ROps but mostly as minor to moderate. In BG, the national water strategy expired without renewal. EL focuses on short-term crisis management, similar to FR and ES where, measures are largely reactive to droughts.

Lack of knowledge among politicians: Here, similar results were reported as in the previous barrier. In DE, a better understanding might have led to a wastewater law more compatible with phosphorus recovery from digestate or its liquor rather than ashes. ES highlighted that some decision-makers are unaware of reuse benefits.

ROp-specific institutional barriers

L**ack of coordination/responsibilities:** This barrier was reported as moderate, and once as a significant issue. Both ES and BG stated that there is an overlap among the different policy levels, local and national, as well as between sectors.

Limited support from authorities: Two ROps reported a barrier related to this topic. In EL, despite growing policy-level recognition of WACES, funding, technical guidance, and political commitment often lack at the regional and municipal levels. In ES, support grows but is inconsistent.

ROp-specific regulatory/legal barriers

Lack of harmonised standards and guidance: Some of the ROps reported this barrier as a minor to moderate issue. For example, in DE, existing fertiliser regulations offer data but no comprehensive framework. IT has not yet adopted the EU Water Reuse Regulation, while ES reported uncertainty about its application. FR lacks plumbing codes for water reuse, and unclear technical assumptions (e.g. water quality limits, barrier distances) complicate solutions for unregulated uses.

Inflexible policy framework: This barrier appeared mainly in two of the ROps. In DE, the wastewater law favours the ash route due to strict recovery requirements. In FR, regulations make limited use of risk-based approaches, while rigid classifications of water source and uses restrict flexibility and innovation.

Time-consuming and complex monitoring: In DE, certification of recovered fertilisers under the EU Fertiliser Product Regulation is complex and costly. In FR, differing regional interpretations create inconsistencies in monitoring points. In ES, the national water reuse legislation introduced extensive monitoring and documentation, which improves safety but increases complexity, particularly for small-scale schemes.

ROp-specific permitting barrier

Barriers regarding permitting were mainly minor to moderate, except for DE, where the certification and end-of-waste declaration of recovered fertilisers under the EU Fertiliser Product Regulation is seen as highly complex and costly, with no institution yet in place to carry out the certification. In BG, procedures for innovative solutions are slow, and validation and certification of new technologies remain inconsistent. In FR, missing national protocols and varying interpretations of risk reduce trust and make projects difficult or even unviable. In ES, the national water reuse law provides a more structured but demanding framework. Furthermore the involvement of multiple authorities causes delays, and high costs remain a barrier for smaller projects.

4.5 Drivers

This section outlines potentially relevant drivers for WACES uptake and implementation within the ROps. To cluster the survey results, they were compared with a set of drivers derived from the literature (source, see Annex VI). In this chapter, the drivers of each of the ROps are summarised based on the different topics, and it is marked in parentheses the countries of the ROps, where the submitted driver relates to. Furthermore, the results from the workshop in Bologna were considered and marked as (WS). However, as the information from the ROps is limited, as it is based on a small number of responses per ROp, the following paragraph provides more of a first starting point of potential drivers than a complete picture, which will be most likely extended in the workshops that follow within the BOOST-IN project. Furthermore, the list from the literature in the Annex VI also serves as a helpful reference point for what else could be considered as helpful drivers.

Natural resource scarcity

Severe environmental pressures, particularly droughts and water scarcity, act as the most potent catalyst for WACES adoption (BG, FR, EL, IT, ES). Furthermore, climate change further intensifies these pressures,

increasing water stress and the need for alternative supply solutions (FR, EL, IT). Indirect potable reuse can contribute to water security and resilience in coastal regions where treated wastewater would otherwise be discharged into the sea (FR). In addition, the potential for nutrient recovery and greenhouse gas reduction provides further drivers, as nitrogen recovery improves effluent quality and reduces eutrophication risks in rivers and coastal waters, while recycling lowers nitrous oxide emissions from wastewater treatment, contributing to climate protection (DE).

Financial

Access to financing and cost allocation facilitates the implementation of WACES. Enhanced access to EU funding programmes such as LIFE and Horizon supports uptake (IT, ES), while subsidies help make circular economy products competitive with conventional ones (ES, WS). Lower operational costs and new revenue streams provide additional drivers. Cost savings from resource recovery and water reuse can further reduce expenses and create opportunities for industries (BG, GR, IT). Industries also see potential long-term financial benefits in reusing water for in-house processes such as cooling, even if these are not yet profitable in the short term (GR). Farmers are increasingly interested in alternatives, especially following sharp fertiliser price increases in 2023 (DE). In some regions, incentives are used to attract new companies, including tax advantages and exemptions from water charges on reclaimed water (WS). In addition, the reduction of wastewater discharge fees provides an indirect financial incentive for reuse (GR).

Technological

The implementation of technology that allows commercial use of by-products after treatment supports the continuation of circular models. For example, recovery of nitrogen and phosphorus with technologies that generate “ready to use” fertiliser provides substitutes for conventional inputs and strengthens the circular economy in the wastewater sector (DE).

Social

A high social value is attributed to freshwater. This can result in a social demand and possibly in a pressure for a better environment protection, which can push the implementation of WACES technology, especially those close to a nature-based solution (BG). Public awareness of water management issues can further drive change. Social pressure reinforces environmental demands, which can lead to pressure on asset managers and elected officials to act (IT, BG). Public support needs to be built to make WACES an indispensable part of resource management (IT).

Communication and knowledge transfer can lead to public support and help environmental policy. This can be conducted e.g. via the promotion of success stories, together with capacity building, to support public openness to water reuse. Furthermore, a better mutual understanding of expectations and tolerances on water origins and overall risk perception can also be an important driver. This can be assisted through improved guidance for water reuse regulation (WS). Growing discourse around eco-labels and sustainability standards motivates industries to adopt circular practices, even if primarily symbolic. Dissemination of best practices and demonstration projects can further increase acceptance and replication potential (GR).

Policy, planning, regulation and governance

Support from regulators, politicians and public representatives alongside regulations making circularity compulsory are essential drivers for WACES implementation. Political will is an essential driver (FR), supported by robust stakeholder engagement (IT).

Wastewater regulation is another strong driver. The new UWWTD introduces stricter effluent limits and raises overall standards for water quality (DE, WS). In parallel, strong and well-established non-potable

quality standards have been developed, including agreements on quality criteria for CE products such as CWA and harmonised standards (WS).

Furthermore, policy integration is central to long-term uptake. A holistic strategic framework can incorporate circular economy principles into regional planning. Reuse schemes embedded in strategic planning support the transformation of the vision of a circular water economy into concrete regional action (IT).

Evidence-based policymaking supports the fulfilment of water and environmental objectives. Updated regulations based on research data and linked to national and regional targets (WS) support uptake. Coordination across levels of government further strengthens implementation. Permanent coordination between governmental bodies and stakeholder networks ensures cooperation on different national levels, while transboundary agreements provide a framework for common action. Cross-sectoral integration also promotes cooperation across water, energy and resource recovery (IT). Clear and functional administrative frameworks can complement these governance structures, providing stability for implementation (IT).

Private sector and stakeholder involvement through public-private partnerships is another important driver. For example, the establishment of a cooperation between WWTPs and farmers supports the motivation to continue circular models and implement WACES (DE, WS). The trust within those partnerships is also essential (e.g., the Braunschweig model in Germany).

4.6 Enabling factors

The following ROp-specific examples (Table 9) highlight the main enabling factors that are submitted by the ROps to create favourable conditions for WACES implementation.

Table 9: Overview of the enabling factors that were submitted by the ROps.

Category	Enabling Factors
Technical	- Technical know-how and expertise (EL, FR) - Technical innovation, digitalisation, and research capacity (IT) - Active research institutions and knowledge transfer hubs (ES) - Expertise from both wastewater treatment and fertiliser production is needed, creating new professional profiles and training opportunities (DE). - Partnerships with fertiliser companies (granulation trials) improve product usability and accelerate scaling (DE).
Economic / Financial	- Own investments by mining companies (BG) - Pilot projects demonstrate feasibility and serve as entry points for EU programmes support (BG) - Access to funding and financing instruments, including EU programmes (BG, EL, IT)
Social	- NGOs and civil society actors raise awareness and collaborate on water-related initiatives (BG). - Public engagement processes and community visitor centres (e.g. pilot projects with education programmes in schools and university [IT]) are essential to build trust and acceptance (FR). - Farmers and agricultural cooperatives open to adopting recovered fertilisers and innovations (DE, ES) - Labelling and consumer information could turn wastewater-derived fertilisers into an asset for organic farming and sustainability branding (DE).

Category	Enabling Factors
	- Pilot projects serve as awareness tools for both industry and local communities, showing that reuse is feasible and safe (EL). - Stakeholder workshops and benchmarking among companies enhance awareness and spread good practice (IT).
Political	- Strategic alignment with national and EU circular economy policies (IT) - Existence of a WACES-supportive narrative in regional strategies (ES) - Participation in international initiatives (IT) - Standardisation and end-of-waste criteria (WS) - Guidance, templates and helpdesks provided by responsible authorities (WS)
Institutional	- Integration across sectors (water, energy, resources) (IT) - Improved cooperation among water supply and sewerage operators (BG) - Municipalities and mayors act as key intermediaries between state and industry (BG). - Research partners provide technical support, training, and ad hoc consulting to industries operating reuse systems (EL). - Intercommunal structures are key actors managing water and wastewater at local level (FR). - Regional health authorities and scientific institutes (e.g. INRA) provide expertise and legitimacy to build trust (FR). - Established cooperation between WWTPs and farmers (e.g. Braunschweig model) (DE) - Motivation of WWTP utilities to maintain the circular model (DE) - Reducing industry influence in advisory systems could help align agriculture with societal sustainability goals (DE). - Strong cooperation protocols between irrigation consortia and WWTPs ensure quality control and emergency management (IT).
Regulatory / Legal	- Expanding the list of eligible uses for reclaimed water (beyond cooling and restricted irrigation) and clearer guidance on risk assessments (EL)
Permitting	- Simplified permitting (IT)

5.0 Discussion

This report assessed in parallel the 24 WACES (Chapter 3) and the regional context across the six ROps (Chapter 4), revealing a set of opportunities, barriers, and necessary framework conditions for the uptake of WACES. While the assessed WACES demonstrate positive technological potential – at least the extent that an assessment was possible –, their success and ultimate impact depend largely on their political, regulatory, and economic integration. The following paragraphs synthesise the most relevant findings and place them in a broader context.

Policy relevance

A central result of the WACES assessment is that they can contribute broadly to EU directives[9]. The strongest connections overall are with the WFD, the GWD, and the UWWTD, which was, in a way, to be expected but confirms the close link of WACES to the core objectives of European water policy. Findings in the Effectiveness assessment (Chapter 3.3) underline the specific contributions WACES can have. Mon[10] support real-time risk management, TPS and TTD improve water quality and enable reuse, while RR closes material cycles. The evidence – based on submitted data and interviews – that supports the effectiveness varies across categories, while TPS, TTD and RR WACES show direct and measurable impacts, MTT and Mon contribute more indirectly.

However, the positive potential contrasts with the results of the policy assessment regarding the ROps, where the enabling environment of WACES in national laws remains inadequate, as they are hardly taken into account. The strategies show a different picture as most of them address WACES more directly. Nevertheless, references to WACES in laws or strategies should not be equated with their actual promotion or implementation. Likewise, even if they are not explicitly mentioned, WACES-related activities may still develop, for instance, through initiatives by local actors working on reuse or recovery. Policy and planning documents, therefore, mainly illustrate prevailing political and/or institutional priorities, intentions and expectations, but they do not or only partially reveal how far WACES are put into practice. A clearer picture of their deployment emerges when looking at practice-oriented evidence, such as funding calls or project documentation, which could be a subject for further research.

Trade-offs and synergies

Although the analysis of potential trade-offs did not generate much evidence, the identified example in the field of resource recovery illustrates the issues that must be considered when implementing WACES. The additional energy demand for the recovery of phosphorus or nitrogen can increase greenhouse gas emissions, creating potential conflicts with energy and climate objectives. This underlines that the evaluation of innovative technologies cannot be one-dimensional. To support evidence-based decision-making, tools like LCA are essential, shifting the responsibility towards policymakers, who need to ensure mandatory assessments in the policy framework. In several ROps, national laws promoting efficiency or a circular approach are already in place, which could help mitigate these trade-offs by following a more holistic approach. It is also important to consider that resource recovery may generate co-benefits – such as reduced dependency on imported fertilisers and enhanced resource security – that can offset potential drawbacks. As a methodological enhancement, future work could test whether the ecological and

[9] Water Framework Directive (WFD), Nitrates Directive (ND), Floods Directive (FD), Drinking Water Directive (DWD), Marine Strategy Framework Directive (MSFD), Groundwater Directive (GWD), Sewage Sludge Directive (SSD), Industrial Emissions Directive (IED), Urban Waste Water Treatment Directive (UWWTD), Renewable Energy Directive (RED), Nature Restoration Law (NRL), Taxonomy Climate and Environment Delegated Acts (Taxonomy DA), Climate Law (ECL)

[10] Monitoring (Mon), Treatment: primary & secondary (TPS), Treatment: tertiary & disinfection (TTD), Management & training tools (MTT), Resource recovery (RR)

chemical status of water bodies immediately downstream of WACES sites have improved between the first and third River Basin Management Plan cycles, acknowledging that feasibility assessments depend on data availability and consistent linkage between intervention sites and monitored reaches. This comparison could provide a more comprehensive and WACES-independent way of reviewing positive impacts and identifying trade-offs that might otherwise be overlooked.

Barriers, enabling factors and drivers

Based on the analysis of drivers, enabling factors and barriers, three key aspects emerge as particularly relevant to the successful implementation of WACES. To illustrate these aspects, a table has been created in which the drivers, enabling factors and barriers are shown side by side (see Annex 7).

The first key aspect is the **regulatory framework.** Clear, coherent and workable rules – grounded in laws and strategic policy documents, established by policymakers and consistently implemented by competent authorities – provide the foundation for predictability. Binding recovery and reuse obligations, together with water reuse or circular economy strategies that offer strategic direction and political legitimacy, constitute strong drivers for WACES implementation. Alignment of national and regional laws and strategies with EU policy framework is particularly important, as it facilitates uptake, upscaling and investment by WACES providers in different countries.

At the same time, the regulatory frameworks can also hamper uptake or lead to higher costs or efforts. Responsibilities among authorities involved in implementing and enforcing legislation are not always well coordinated, resulting, for example, in fragmented product approval procedures, or lengthy and costly end-of-waste certification for recovered products. In the context of reuse, legally mandated monitoring requirements may be disproportionate to the scale of projects, hampering small scale WACES and making them economically or administratively unfeasible. Although, some WACES offer real-time monitoring solutions that could reduce monitoring costs, their effectiveness depends on whether the generated data are certified and formally accepted by the competent authorities.

These regulatory burdens create transaction costs and delays that can outweigh the intended enabling effect, limiting the broader deployment of WACES Regulation thus is a double-edged factor: it can act as a strong driver by providing legal certainty, but it can equally slow it down when procedures are complex or inconsistently applied.

Germany – Regulatory frameworks and recovery
Germany shows how binding obligations can both drive and complicate uptake. The legal requirement for phosphorus recovery creates a strong driver, but at the same time strict fertiliser regulations slow down the market entry of recovered products. These parallel dynamics illustrate the double-edged nature of regulation.

France – Environmental drivers, but regulatory inflexibility
Severe droughts, particularly in 2022, exposed the vulnerabilities of France's water supply and intensified debate around water reuse solutions. In response, national policy announcements set a target of 1,000 new water reuse or other non-conventional water projects by 2030. However, this environmental pressure is undermined by regulatory rigidity. Classifications of water sources and uses remain inflexible, and the absence of national protocols leaves room for inconsistent regional interpretations. These inconsistencies not only complicate monitoring but also erode trust among stakeholders, making projects challenging or even unfeasible

The second key aspect concerns **risk and uncertainty**, which appear especially in permitting procedures, through unpredictable social dynamics and from technological constraints, such as compatibility with

existing infrastructure. A central issue is institutional capacity, as authorities may lack the expertise or resources to evaluate new technologies consistently, leading to requirements that potentially favour established technologies.

Infrastructural readiness is another critical factor, as some WACES depend on distribution networks for recovered water or other resources. Where such infrastructures are absent, implementation becomes technically unfeasible or more expensive. By contrast, WACES designed with modularity can be more easily integrated into existing systems, helping to manage knowledge gaps and reducing the need for staff to adapt to an entirely new configuration.

Operational reliability under different local conditions also remains a concern, as performance data are often limited due to the small number of existing facilities. In addition, social acceptance plays a critical role, since uptake can be slowed if users question the safety or quality of reclaimed water and recovered products. Levels of trust or mistrust are highly location-specific and can vary considerably between regions, requiring context-sensitive stakeholder management.

Addressing these dimensions of risk requires not only clearer procedures and responsibilities, but also stronger institutional capacity, targeted infrastructure upgrades and measures that build confidence in both the technologies and their outputs.

Greece – Strategic ambition constrained by infrastructure gaps
In Greece, strategies recognise reuse as a key adaptation measure, especially under conditions of water scarcity. However, many wastewater treatment plants still lack tertiary stages, which technically prevents implementation. This shows how infrastructural deficits can act as decisive barriers despite policy support.

Bulgaria – Institutional weakness offset by private initiative
Bulgaria demonstrates the role of institutional weaknesses as barriers. Limited administrative resources, unclear responsibilities embedded in a fragile political surrounding hamper implementation and create uncertainty. At the same time, private actors in the mining sector have initiated recovery projects, showing that drivers can emerge even in weak institutional contexts.

Italy – Political will but legal uncertainty
In Italy political will and stakeholder engagement act as an enabler for WACES. At the same time, the incomplete adoption of the EU Water Reuse Regulation creates legal uncertainty, leaving operators without a fully reliable framework for implementation. This illustrates how even under favourable political conditions, regulatory gaps can delay the transition from strategy to practice.

The third key aspect is **economic viability**, which depends on investment costs, tariff structures and economic revenues for reclaimed water and recovered products. This element was consistently identified as the most critical barrier among the WACES, but also by the ROps. Many WACES face high capital costs and long payback periods, making it unattractive for investment and upscaling. Where tariffs for water are low and do not reflect real operational costs, reclaimed water struggles to compete with conventional supply. Regarding WACES that recover resources, weak markets and low prices for recovered fertilisers limit profitability, even when technical feasibility is given. These economic barriers explain why many solutions remain confined to pilot projects despite their proven effectiveness. At the same time, there are enablers that can improve the financial basis. Subsidies, EU and national funding programmes, and tax incentives reduce investment risks. In some cases, cost savings or additional revenues – for example, through additional energy generation from sludge – can strengthen the business case. Nevertheless,

without more systemic changes such as cost-reflective tariffs, better market development for recovered products and stable operating support, economic conditions remain the decisive bottleneck.

Spain – Economic demand limited by tariff structures
Spain illustrates the economic imbalance faced by many WACES. Very low water tariffs make reclaimed water less competitive than conventional supply, even though droughts create strong demand. Subsidies and investment in distribution infrastructure help reduce this gap, but long-term viability remains fragile.

When these three elements align, WACES can be scaled-up, but if one of them fails, projects tend to remain pilots or isolated showcases.

Summarised policy recommendations

The following recommendations are based on the analysis of the enablers, drivers and barriers reported by both the WACES and the ROPs. Furthermore, each of the ROps submitted region-specific recommendations, which have also been considered. These are preliminary recommendations, which will be further elaborated in Deliverable 3.3., which may lead to different pathways after receiving feedback from the stakeholders in the planned policy workshops.

General recommendations

- Develop a fair and standardised pricing model for water - including reclaimed water and recovered products on a national level but also across the EU.
- Launch communication campaigns and stakeholder engagement initiatives at all levels (EU and national and local) to address public distrust and misinformation.
- Improve guidance and certification process to better integrate real time monitoring systems in the mandatory quality assurance to reduce reliance on costly laboratory testing.
- Harmonise permitting requirements and timelines, including time limits for decisions and simplified protocols for small-scale projects.
- Strengthen training and capacity-building programmes for authorities, utilities and operators, to address knowledge gaps and overcome stereotypes.
- Promote long-term strategic planning obligations that go beyond short-term crisis management, embedding WACES into climate and water resilience strategies.

Bulgaria:

- Adopt a specialised Water Supply & Services Act to clarify roles and integrate financing, monitoring and enforcement across the sectors.
- Develop national and regional (Srednogorie) WACES strategy with measurable targets.
- Enforcement of universal metering and leakage control to prevent non-regulated use and water theft.
- Prioritise WWTP construction and upgrades with reuse-ready designs.
- Focus on ensuring compliance with the DWD, especially in smaller settlements.

France:

- Establish financing mechanisms for water reuse beyond tariff recovery.
- Require tertiary and disinfection treatment to enable water reuse in line with the revised UWWTD.
- Shift national regulations towards a proportionate risk-based approach for reuse authorisations, or, where prohibitions remain, provide transparent technical guidance explaining the rationale for excluded water sources and uses.

Germany:

- Impose targeted taxes or subsidies on primary resources to improve competitiveness.

- Streamline end-of-waste and certification procedures for recovered fertilisers.
- Mandatory share of recovered products in conventional fertilizers as “market pull” rather than pushing recovered fertilizers in the market via mandatory recycling.
- Enable cooperative WWTP-farmer platforms to create local markets

Greece:

- Establish a centralised permitting process via a single authority, with one application route, unified checklists and clear timelines to lower transaction costs.
- Reform water tariffs and introduce performance-based incentives (e.g. outcome-linked subsidies, volumetric reuse credits).
- Create a regulatory framework for the enabling of cross-sector water and resource exchanges in industrial and agricultural clusters.
- Launch of a national capacity-building programme for municipalities and utilities (e.g. planning, risk management plans, monitoring design, stakeholder engagement).
- Upgrade and implementation of reuse infrastructure (tertiary steps in WWTPs, pipelines, storage) prioritising islands and water-scarce areas.
- Implement smart metering and network modernisation to enable water reuse and make it financially attractive.

Italy:

- Modernise and expand water infrastructure by upgrading wastewater treatment plants for high-quality reuse, expanding reservoirs, and constructing dual water networks for varied uses in urban areas as well as efficient irrigation systems in agriculture.
- Advance the digitalisation of water systems to enable real-time monitoring, data-driven decision-making, and compliance tracking.
- Increase investment in reclaimed water distribution systems by bridging infrastructure gaps, particularly for separate pipelines and quality monitoring systems.
- Simplify and harmonise regulatory frameworks across regions to reduce administrative burdens, accelerate permitting, and ensure consistent enforcement.
- Expand dedicated and sustained financial instruments and incentives to support infrastructure upgrades, digital solutions, and decentralised approaches, while leveraging public–private partnerships to mobilise additional resources.
- Set ambitious and legally binding national targets for water reuse with clear milestones and region-specific objectives to accelerate implementation.
- Promote WACES awareness and capacity building through national campaigns and training programmes to strengthen stakeholder engagement and foster cultural change.
- Improve institutional coordination across governance levels (national, regional, and local) to overcome fragmented responsibilities and ensure consistent implementation of circular water policies.

Spain:

- Fully harmonise national rules with the EU Water Reuse Regulation and clarify the regional implementation to give legal clarity.
- Define proportionate tertiary treatment obligations for small WWTPs and development of simplified models for small-scale reuse schemes to keep compliance affordable.
- Set clear national monitoring and traceability standards for water reuse.
- Establish a clear multi-year funding line for rural and agricultural circular-water projects.
- Adjust water tariffs and invest in infrastructure to improve the competitiveness and viability of reclaimed water.

6.0 Conclusion and further steps

The findings of this deliverable provide insights into how WACES interact with the current policy and planning environments across the six ROps. They capture current dynamics and systemic barriers but also highlight drivers and opportunities that can inform future policy development. At this stage, the results are intended to encourage reflection on the decision-making processes, practical tools, and the involvement of stakeholders. They provide a foundation for dialogue and engagement, enabling the identification of key challenges as well as the exploration of innovative approaches to WACES. The analytical framework developed and applied here can also serve as a baseline for other case studies by supporting the advancement of water circular economy initiatives. Building on the results of Task 3.2, the upcoming Task 3.3 will refine these findings through regional workshops with policymakers, practitioners and local stakeholders, validating the conclusions and adding new perspectives from local contexts and the general public. The outputs will feed into Deliverable 3.3, which will formulate specific policy recommendations for promoting WACES at regional and EU levels, with a particular focus on the European Green Deal and related policy instruments. These recommendations will be developed collaboratively, translated into several languages for regional dissemination, and further communicated at EU level to maximise their policy impact.

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Annex I: Policies addressed

Table 10 provides an overview of which policies are addressed by each WACES selected, highlighting potential synergies between innovative solutions and EU regulatory objectives.

Table 10: Overview of policies that are addressed by the different WACES.

Country/ Category	Bulgaria				France				Germany				Greece				Italy				Spain			
Mon		x													x	x	x		x	x		x		
TPS	x		x				x	x					x					x			x			x
TTD					x		x						x	x				x			x		x	x
MTT		x		x																				x
RR	x					x	x		x	x	x	x												
WACES Nr./EU Directive	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**	**24**
WFD																								
GWD																								
DWD																								
FD																								
MSFD																								
ND																								
SSD																								
IED																								
UWWTD																								
RED																								
NRL																								
ECL																								
Taxonomy DA																								

Description of the overall score Σ:

High coverage: The WACES contributes to five or more policies (out of the 12) EU directives, showcasing strong alignment with policy objectives and a comprehensive impact across a wide spectrum of policy areas.	
Moderate coverage: The WACES contributes to up to five policies, demonstrating partial alignment with policy objectives and a somewhat still focused impact across multiple policy areas.	
Not applicable: The answer in the questionnaire was left out. Therefore, no information is available.	

Annex II: Trade-offs

Table 11 provides an overview of the WACES objectives, the associated country and the trade-offs identified during the WACES assessments.

Table 11: Overview of identified trade-offs.

Country/ Category	Bulgaria				France				Germany				Greece				Italy				Spain			
Mon		x													x	x	x		x	x		x		
TPS	x		x				x	x					x					x			x			x
TTD					x		x						x	X				x			x		X	x
MTT		x		x																				x
RR	x					x	x		x	x	x	x												
WACES Nr./ EU Directvie	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**	**24**
WFD																								
GWD																								
DWD																								
FD																								
MSFD																								
ND																								
SSD																								
IED																								
UWWTD																								
RED																								
NRL																								
ECL																								
Taxonomy DA																								

Colour code for individual policy.

Yes Trade-off: Indicates that the WACES presents at least clear trade-offs with policy objectives. These conflicts may undermine the achievement of the directive's goals and would require substantial modifications or strategies to balance the competing interests.	
Potential Trade-off: This represents a situation with a possibility of minor trade-offs. The WACES may align with policy goals but could require adjustments or specific considerations to fully mitigate potential conflicts.	
No Trade-off: Indicates that no significant trade-offs are expected. The WACES aligns well with the policy objective, showing full compatibility with the directive, law or act without compromising other goals.	
Not Applicable: Indicates that the directive does not apply to the specific WACES being evaluated. There is no direct relationship or impact to consider, and therefore no trade-offs are relevant.	

Colour code for the overall score:

Several Trade-offs: Indicates that the WACES presents at least two trade-offs with policy objectives (yellow or red).	
Yes Trade-off: The WACES has one trade-off with a policy objective (yellow or red).	
No Trade-off: No significant trade-offs appeared in any of the policies.	
Not Applicable: Indicates that the directive does not apply to the specific WACES being evaluated. There is no direct relationship or impact to consider, and therefore no trade-offs are relevant.	

Annex III: Effectiveness on the ground

Table 12 presents an overview of measurable contributions made by different WACES to specific EU directives, illustrating the practical impact assessed by interviews and literature research. Table 12 depicts the WACES technology type, the country and the different EU directives that the WACES potentially contribute to. Most WACES (7) significantly contribute to reaching the targets determined in the Water Framework Directive (WFD). Four WACES significantly contribute to achieving the targets in the Drinking Water Directive (DWD), Sewage Sludge Directive (SSD), and the Urban Wastewater Treatment Directive (UWWTD). Three significantly contribute to reaching the targets in the Groundwater Directive (GWD), two to the Nitrates Directive's (ND) goals, as well as the European Climate Law's (ECL) aims. One WACES equally significantly contributes to the Industrial Emissions Directive (IED), the Nature Restoration Law (NRL) and the TEU Taxonomy Climate and Environment Delegated Acts (Taxonomy DA).

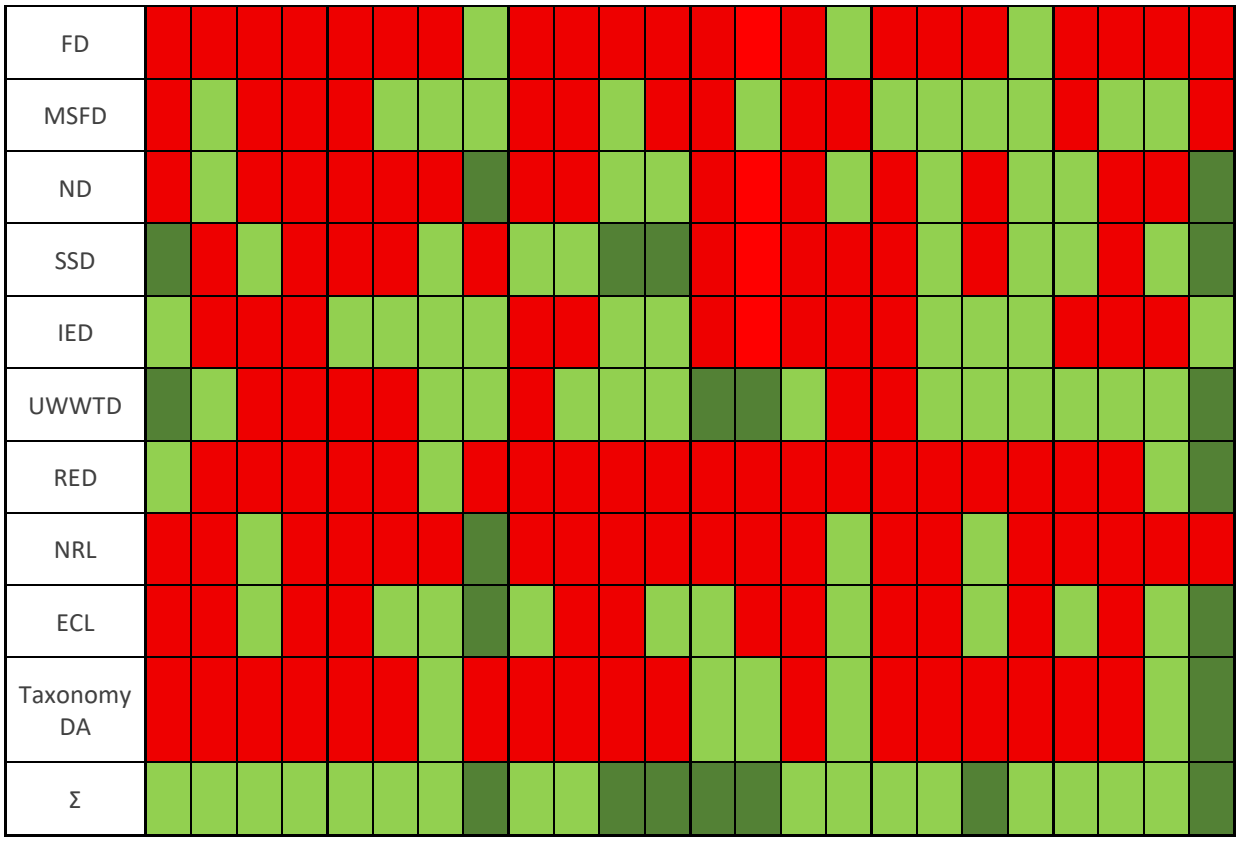
The WFD also has the most minor positive contributions (15), followed by the GWD (14), the UWWTD (13), the Marine Strategy Framework Directive (MSFD) (12), and the IED, as well as the ECL (equally 10). The SSD (8), DWD and ND (7) are followed by the Taxonomy DA (5) and the Floods Directive (FD) (3), as well as the Renewable Energy Directive (3) and NRL (3).

Merely one WACES does not contribute to meeting the WFD's targets, whereas 21 WACES do not contribute to the FD. 20 WACES also do not contribute to meeting the aims of neither the RED nor the NRL, raising the question of whether this is a realistic WACES aim.

Overall, seven out of 24 WACES significantly contribute to meeting EU policy targets, which is less than a third. The rest (17) have a minor contribution, because in the overall assessment, at least one minor contribution was determined. No WACES has no contribution.

Table 12: Overview of measurable contributions of WACES to EU directives

Country/ Category	Bulgaria				France				Germany				Greece				Italy				Spain			
Mon		x													x	x	x		x	x		x		
TPS	x		X				x	x					x					x			x			x
TTD					x		x						x	x				x			x		X	x
MTT		x		x																				x
RR	x					x	x		x	x	x	x												
WACES Nr./ EU Directvie	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**	**24**
WFD																								
GWD																								
DWD																								



Colour code for individual policy:

Significant contributions: The implemented WACES has made (or is expected to make) significant contributions to achieving the EU circular economy policy objectives in the implementation location.	
Minor contributions: The implemented WACES has made (or is expected to make) minor contributions to achieving the EU circular economy policy objectives in the implementation location.	
No contributions: The implemented WACES has made (or is expected to make) no contributions to achieving the EU circular economy policy objectives in the implementation location.	

Colour code for overall score (Σ):

Significant contributions: Three of more significant contributions are achieved.	
Minor contributions: Less than three significant contributions are achieved.	

Annex IV: ROp relevant circular economy policies

Table 13: Overview of the relevant policies for CE submitted by the ROps.

Country	Law name	Nr.	Category
Bulgaria	Water Act	1	water in general
	Energy Act	2	energy
	Energy from Renewable Resources Act	3	renewable energy
	Energy Efficiency Act	4	energy efficiency
	Waste Management Act	5	waste
	Ordinance on protection from nitrate pollution (Nitrates Ordinance)	6	fertiliser
	Ordinance on permits for water use (Ordinance on surface-water use permits, 2021)	7	water permits
France	Law on the energy transition for green growth (Loi relative à la transition énergétique pour la croissance verte (TEPCV))	8	climate/energy
	The Anti-Waste Law for a Circular Economy (La loi anti-gaspillage)	9	circular economy
	Decree No. 2023-835 of 29 August 2023 (décret n°2023-835 du 29 août 2023)	10	water reuse
	Decree of 14 December 2023 (Watering green spaces)	11	water reuse
	Decree of 18 December 2023 (Agricultural irrigation)	12	water reuse
	Decree of 8 September 2025 (Urban uses)	13	water reuse
Germany	Abwasserverordnung	14	wastewater
	Klärschlammverordnung	15	wastewater
	Düngegesetz	16	fertiliser application
	Düngemittelverordnung	17	fertiliser
	Grundwasserverordnung	18	groundwater
	Wasserhaushaltsgesetz	19	water in general
	Verordnung zum Schutz oberirdischer Gewässer	20	surface water
	Bundes-Immissionsschutzgesetz	21	emission control
Greece	Law 3199/2003	22	water in general
	Joint Ministerial Decision (JMD) No. 145116/2011	23	water reuse
	Ministerial Decision No. οικ. 191002/2013	24	water reuse
Italy	TESTO UNICO AMBIENTALE - Decreto Legislativo 3 aprile 2006, n. 152- ENVIRONMENTAL CODE - Legislative Decree 3 April 2006, no. 152;	25	environmental
	Regolamento sul Riuso Idrico (DM 185/2003) - Water Reuse Regulation (Ministerial Decree 185/2003)	26	water reuse
	LEGGE 13 giugno 2023, n. 68 - Urgent provisions for combating water scarcity and for the enhancement and adaptation of water infrastructure.	27	drought/water infrastructure
	Decreto-Legge 14 Aprile 2023 n. 68 DECRETO SICCITÀ - DROUGHT DECREE	28	drought/water infrastructure/water reuse
	LEGGE 28 dicembre 2015, n. 221 - Environmental provisions to promote green economy measures	29	environmental/green economy

Spain	RD 1085/2024 Transposition of Regulation (EU) 2020/741 on minimum requirements for water reuse	30	water reuse
	RD 1620/2007 Old Spanish Royal Decree on reclaimed water	31	water reuse
	RD 1085/2024 Transposition of Regulation (EU) 2020/741 on minimum requirements for water reuse)	32	water reuse
	Ley 9/2010 de Aguas de Andalucía	33	regional water in general
	Ley 3/2023, de 30 de marzo, de Economía Circular de Andalucía.	34	environmental/green economy/climate
	Real Decreto Legislativo 1/2001, de 20 de julio, por el que se aprueba el texto refundido de la Ley de Aguas.	35	water in general

Table 14: Overview of the relevant strategies for CE submitted by the ROps.

Country	Strategy name	Nr.	Strategy category
Bulgaria	National Strategy for Development of the Water Sector	1	water in general
	National Energy and Climate Plan	2	climate/energy
	Strategy for circular transition	3	circular economy
	River basin management plans (RBMP)	4	river basin management
France	The Water Plan (Plan Eau): “Action plan for resilient and concerted water management”	5	water in general
Greece	National Circular Economy Strategy (2018) & Action Plan (2021)	6	circular economy
Italy	Piano di gestione delle acque 2021-2027 dell’Autorità di bacino distrettuale del fiume Po - Po River Basin District Authority's Water Management Plan 2021-2027	7	river basin management
	PGA 2022-2027 ;Autorità di bacino distrettuale dell’Appennino centrale - PGA 2022-2027; District Basin Authority of the Central Apennines ;	8	river basin management
	Strategia nazionale per l’economia circolare - National circular economy strategy	9	circular economy
	Piano di tutela delle acque (2030) / Water Protection Plan	10	water protection
	Piano “111 opere” - 111 Projects' Plan	11	investment plan
Spain	Hydrological Plan for the Guadalquivir River Basin (2022–2027)	12	river basin managment
	Andalusian Climate Action Plan (PAAC 2021–2030)	13	climate
	Hydrological Plan for Cuencas Mediterraneas River Basin (2022–2027)	14	river basin managment

ANNEX V: Detailed barriers of the ROps

Table 15: Full list of the barriers submitted by each of the ROps.

Barrier types	Specific barriers	Country	Barrier level (X)				Explanation/Potential solution
1. Technology	1.1. Lack of availability	BG			X		Limited availability of modern solutions for treating specific pollutants from mining activities. Technology transfer and adaptation to local conditions are needed.
		DE	X				
		EL	x				
		IT	x				
		FR	X				
		ES	X				
	1.2. Lack of feasibility	BG			X		Some facilities in the mining industry have limited space and complex infrastructure requirements, making it difficult to implement new water technologies without significant investment.
		DE	X				
		EL	X				
		IT	X				
		FR	X				
		ES	X				
	1.3. Lack of consistency	BG	X				
		DE					Does not apply to nutrient recovery.
		EL		x			Validation and performance assessment procedures for innovative WACES technologies are not standardized across Greece. Certification pathways are under development, but lack of national protocols affects trust and market uptake.
		IT		x			
		FR			x		Validation processes are standardized nationally; however, the implementation varies across different departments where authorizing officers may have differing interpretations of risk levels and therefore impose quite different modifications on technology or risk reduction practices. Sometimes, the restrictions imposed mean the projects become close to or actually unviable.
		ES	X				
	1.4. Technical limitations	BG	X				

		DE	X				Depending on the technology and the chosen process, very high fertilizer qualities can be reached
		EL	X				
		IT			x		
		FR	X				
		ES	X				
	1.5. Lack of infrastructure	BG	X				
		DE		x			Logistics for fertilizer distribution are challenging, but do exist. For ash technologies: mono-incinerator mandatory
		EL			x		Many WWTPs lack tertiary treatment and distribution systems for reuse, especially in rural/agricultural zones. Infrastructure gaps require substantial investment and redesign to enable reuse.
		IT	X				
		FR			x		Treatment and delivery infrastructure is almost always not present prior to the design of a project. The costs associated are a significant barrier.
		ES			X		Many rural areas in Andalusia lack pressurized networks to distribute reclaimed water to agricultural plots. Investment in local pipelines and on-farm storage is needed.
	1.6. Lack of efficiency	BG	X				
		DE			X		Depending! Struvite: N and P recovery, integrated in WWT process, contribute to a better effluent quality of a WWTP Ash: Some processes produce (liquid) waste streams that need to be handled
		EL	x				
		IT		x			
		FR	x				
		ES	x				
	1.7. Remaining uncertainty	BG	X				
		DE			x		Depending! Struvite: Low efforts, very high fertilizer qualities can be reached, but lower recovery rates Ash: Either (1) low efforts, lower fertilizer qualities and very high recovery rates or (2) high efforts, higher fertilizer qualities and high recovery rates.
		EL	x				
		IT		x			
		FR	x				

		ES		x			Although many projects show positive results, farmers remain uncertain about long-term soil and crop impacts. More long-term trials and dissemination needed.
	1.8. Need for training and capacity building	BG	X				
		DE			x		Innovative technologies require training and capacity building for plant operators, especially for ash processes (processes more similar to chemical industry than WWTP operation)
		EL	x				
		IT		x			
		FR	x				
		ES				x	Farmers and even some plant operators lack training on safe reuse. A regional program for technical training and certification would help bridge this gap.
2. Economic / Financial	2.1. Need for financial aid	BG				X	High initial investments for modern water treatment plants and water reuse. Subsidies or public-private partnerships are needed.
		DE				x	Financial aid is needed; the market values of the fertilizers are not high enough to economically operate the production process
		EL				x	Substantial financial support is required to implement WACES, especially in smaller municipalities and rural regions. While EU and national funding exist, high capital costs still limit uptake without targeted subsidies.
		IT			x		In the case of water reuse, it needs to be clear who pays for additional treatment – citizens, farmers or some else.
		FR				x	Substantial financial support is required to implement WACES, especially in smaller municipalities and rural regions. While EU and national funding exist, high capital costs still limit uptake without targeted subsidies.
		ES			x		Initial investments for tertiary treatment and infrastructure are high. EU co-financing (e.g., through PERTE or CAP) should be prioritized.
	2.2. Absence of standardised pricing	BG	X				
		DE			x		The market value of recovered nutrients without further processing is too low to turn it into a successful business model, the market volume is also important, hence fertilizer industry is interested in high volumes.
		EL				x	There is no consistent pricing mechanism for reclaimed water in Greece.
		IT			x		The same as above.
		FR			x		There is no consistent pricing mechanism for reclaimed water in France.
		ES	x				
	2.3. Lack of research funding	BG	X				
		DE		X			Funds for R&D and demo plants are available, but decreasing. Further references in real environment could help the concept.

		EL			x		While EU-funded projects (e.g., Horizon Europe, LIFE) support innovation, national-level R&D funding for WACES is limited and sporadic.
		IT			x		Additional treatment needed to enable water reuse can be rather costly.
		FR			x		While EU-funded projects (e.g., Horizon Europe, LIFE) support innovation, national-level R&D funding for WACES is limited and sporadic.
		ES	x				
	2.4. Low financial attractiveness	BG				X	The mining industry does not perceive water innovations as economically viable due to a long payback period.
		DE				X	Market value of fertilizers is not high enough to recover investment and operational costs. However, synergies with improved WWTP treatment efficiency help to finance the concept or via gate-fees for ash treatment.
		EL		x			
		IT		x			
		FR				x	The low cost of water and the relative availability of surface water and ground water sources reduces the financial attractiveness of projects.
		ES			x		Long payback periods discourage adoption. Consider economic incentives like reduced water fees or tax breaks for reuse adopters.
	2.5. Lack of market demand	BG	X				
		DE				x	Secondary fertilizers compete with conventional fertilizers, which are often less costly and in high volumes commercially available and therefore known by farmers.
		EL			x		In areas with abundant conventional sources (e.g., groundwater for agriculture), there is little incentive to use reclaimed water. Public perception also affects willingness to pay.
		IT		x			
		FR				x	The low cost of water and the relative availability of surface water and ground water sources reduces the demand for WACES projects.
		ES	x				
	2.6. Lack of an intelligent price system	BG	X				
		DE					
		EL			x		Water tariffs in Greece typically reflect volume-based charges and do not account for environmental or resource recovery benefits, discouraging reuse practices.
		IT		x			
		FR		x			
		ES		x			True cost of reuse is not reflected in water pricing. Rebalancing tariff structures and including externalities could help.

	2.7. Economic uncertainty	BG			X		The political unstability in Bulgaria consequently brings down the economic trust. For example in the past few years we had several parliament elections.
		DE				X	Long-term economic viability of nutrient recovery is still in question. Following the German legislation, the wastewater producer will pay for nutrient recovery.
		EL	x				
		IT		x			
		FR	x				
		ES	x				
3. Social	3.1. Concerns about potential environmental or social impacts	BG			X		Public distrust regarding the safety and effectiveness of recycled water for agricultural or industrial use.
		DE		X			Farmers used it as long as it the recovered fertilizers are less expensive than conventional fertilizers. The challenge is to guarantee a constant composition of the fertilizers, even though they are of a very high quality. The quality (e.g. plant availability, pollutant concentration) is even better than that of phosphate rock being used in organic farming.
		EL			x		
		IT		x			
		FR			x		Reticence about water circular economy projects exists in many areas due to the perception that the practice is reinforcing damaging economic models that are too focused on economic growth for the interests of big business. For example, prioritizing large-scale monoculture irrigation projects instead of for independent farms.
		ES		x			Public and farmer perception of "dirty water" still persists. Awareness campaigns and transparent monitoring results can help build trust.
	3.2. Economic concerns	BG			x		The same as the above
		DE					
		EL		x			
		IT			x		
		FR		x			Some concerns still exist, but it is diminishing
		ES	x				
	3.3. Lack of available information	BG	X				
		DE		x			Not clear, if especially organic farmers just do not have the knowledge, that these alternative to phosphate rock exists.
		EL		x			
		IT		x			

		FR		x			
		ES	x				
	3.4. Spread of misinformation	BG	X				
		DE		x			Information on high quality and effectiveness of secondary fertilizers is available to farmers. Hence, we talk about a wide range of processes and products, it may occur that misinformation will be spread (e.g. if some recovered fertilizer without heavy metal removal is polluted → misconception: all recovered fertilizer are polluted, but this strongly depends on the underlying recovery process.
		EL		x			
		IT			x		
		FR		x			
		ES		x			Rumors about risks (e.g. microplastics) deter use. Coordinated communication strategies with farmers' associations are needed.
	3.5. Inadequate community engagement	BG		X			The public engagement in water issues is not enough.
		DE	x				
		EL		x			
		IT			x		
		FR		x			
		ES	x				
	3.6. Exacerbation of Inequalities	BG	X				
		DE					
		EL	x				
		IT	x				
		FR			x		See comment for 3.1
		ES	x				
4. Political	4.1. Lack of circular economy framework	BG				X	At the national level, there is a lack of an integrated circular economy strategy in the water sector, which hinders initiatives in industrial regions such as Srednogoria.
		DE		x			In Germany, at least, the AbfKlärV 2017 will increase phosphorus (P) recovery as it will become mandatory for large wastewater treatment plants (WWTPs) with > 50,000 or more PE in 2032. However, the ash route may be favoured due to the law's strict requirements (high recovery rates). Waste regulation is often an obstacle for recycling.

		EL		x			Greece has a National Circular Economy Strategy and a 2021–2025 Action Plan, but water reuse is still not fully integrated into mainstream water policies. The framework exists, but deeper cross-sectoral implementation is needed.
		IT		x			
		FR	x				
		ES	x				
	4.2. Lack of long-term planning	BG			X		Even though there was a National strategy for the improvement of water sector it expired last year and is not renewed.
		DE					
		EL		x			Water policy often focuses on short-term crisis management (e.g., drought response), with limited integration of long-term reuse planning.
		IT		x			
		FR			x		Water circular economy measures and funding have tended to be reactive to drought events and limited in duration.
		ES			x		Many reuse initiatives are reactive (e.g., during droughts). Integrate WACES more explicitly into regional drought and agriculture strategies.
	4.3. Rigid political structures	BG	X				
		DE			x		Limited adaptability: For P recovery, the ash route may be favoured due to the law's strict requirements (high recovery rates).
		EL		x			
		IT		x			
		FR	x				
		ES	x				
	4.4. Communication challenges	BG	X				
		DE					
		EL		x			
		IT			x		
		FR		x			
		ES	x				
	4.5. Lack of knowledge among politicians	BG	X				
		DE			x		If there were a better understanding of the processes, perhaps the AbfKlärV would have been written in a way that better complies with phosphorus recovery from digestate or its liquor instead of from ashes.

		EL		x			
		IT		x			
		FR		x			
		ES			x		Some decision-makers remain unaware of reuse benefits. Training workshops and exposure visits for policy makers can address this.
	4.6. Poor understanding of stakeholder needs	BG	X				
		DE			x		If there were a better understanding of the processes, perhaps the AbfKlärV would have been written in a way that better complies with phosphorus recovery from digestate or its liquor instead of from ashes.
		EL	x				
		IT	x				
		FR	x				
		ES	x				
5. Institutional	5.1. Lack of coordination/responsibilities	BG			X		There is an overlap of competencies between local and national institutions regarding water management.
		DE	x				
		EL			x		
		IT		x			
		FR	x				
		ES				x	Overlapping roles of regional water, environment, and agricultural bodies create confusion. A dedicated coordination body or WACES hub could streamline action.
	5.2. Policy capacity gaps	BG	X				
		DE	x				
		EL	x				
		IT			x		
		FR	x				
		ES	x				
	5.3. Limited support from authorities	BG	X				
		DE	x				
		EL		x			While there is growing recognition of WACES at the policy level, actual implementation support—especially funding, technical guidance, and political

							commitment—is often missing at regional and municipal levels.
		IT	x				
		FR	x				
		ES			x		Support is growing but inconsistent. Boost institutional commitment via regional WACES roadmap and budget.
	5.4. Short-term perspective	BG	X				
		DE	x				
		EL	x				
		IT	x				
		FR	x				
		ES	x				
	5.5. Lack of institutional knowledge	BG	X				
		DE			x		To declare the end-of-waste status according to the Fertilizing Product Regulation (2019/1009), a certification process of recovered fertilizers is needed. This process is very complex and costly. In Germany, there is no institution yet which offers to conduct the certification process.
		EL	x				
		IT	x				
		FR	x				
		ES	x				
6. Regulatory & Legal	6.1. Lack of harmonised standards	BG	X				
		DE	x				Fertilizing Products Regulation (2019/1009) or German DüMV provides data for standardization (nutrient content, thresholds for pollutants)
		EL	x				
		IT			x		The new European regulation on minimum requirements still needs to be adopted in Italy which delays further application of water reuse projects.
		FR		x			Absence of plumbing codes for greywater, water reuse. International standards (ISO) seen to not meet the needs of the French market. Efforts underway from the French standards body (AFNOR) to create French-specific standards.
		ES			x		Confusion about implementation of EU Regulation 2020/741 still exists. Need for Andalusian-level guidance and alignment with national adaptations.
	6.2. Lack of regulatory and technical guidance	BG	X				
		DE	x				Fertilizing Products Regulation (2019/1009), AbfKlärV 2017

		EL	x				
		IT			x		
		FR			x		The reasoning and technical assumptions underlying the existing regulations (water quality limits, barrier distances, etc.) are not clear. Given only some water sources and end uses are regulated, this makes it difficult to assess how to approach currently unregulated sources/uses and propose treatment/management solutions that will be acceptable to the regulatory authorities.
		ES			x		Despite the new RD, many local entities and reuse operators need practical guidance to implement Risk Management Plans (RMPs) and quality monitoring schemes. Workshops and national templates can bridge this gap.
	6.3. Lack of regulatory clarity	BG			X		Ambiguities in the implementation of the European regulation on water reuse (2020/741), especially in industrial applications.
		DE					
		EL	x				
		IT			x		
		FR			x		See above response.
		ES		x			RD 1085/2024 provides a harmonized framework aligned with EU law, reducing previous legal uncertainty for agricultural reuse. However, awareness and correct interpretation by local authorities is still evolving.
	6.4. Inflexible policy framework	BG		X			The policy framework in general is strict but the mining companies always find their way.
		DE			x		AbfKlärV 2017 - limited adaptability: The ash route may be favoured due to the law's strict requirements (high recovery rates).
		EL	x				
		IT			x		
		FR			x		There is limited reference to a risk assessment approach in the current regulations and where it exists, there are numerous additional obligatory compliance measures that do not allow for a risk assessment approach. The regulatory approach attempts to define many types of water, sometimes based on the source, sometimes based on the end use, and disallows certain sources for certain uses regardless of the treatment or water quality.
		ES	x				
	6.5. Time-consuming and complex monitoring	BG	X				
		DE				x	Certification process of recovered fertilizers according to EU (2019/1009) is needed. This process is very complex and costly.
		EL	x				

		IT		x			
		FR		x			The location of monitoring points imposed can vary from one geographical department to another as the regulations are interpreted differently.
		ES			x		RD 1085/2024 requires comprehensive quality control and documentation. This adds complexity but improves safety. Simplified models for small-scale reuse schemes are needed.
	6.6. Degradation of water and soil quality	BG		X			According to some of the local population there are some issues with the discharges water/waste but as far to our knowledge everytime there is an issue after authorities get in the problem is being resolved
		DE					
		EL	x				
		IT		x			
		FR	X				
		ES	x				
	6.7. Lack of safety for agricultural products	BG	X				
		DE	X				Recovered products are of high quality and pose no harm to crops. See Kleyböcker et al. 2024
		EL		x			
		IT		x			
		FR		X			
		ES	x				
7. Permitting procedures	7.1. Lengthy permitting process	BG			X		Permit processes are lengthy, especially for innovative solutions related to water treatment and reuse.
		DE				x	Certification process of recovered fertilizers according to EU (2019/1009) is needed. This process is very complex and costly.
		EL			x		
		IT		X			
		FR		X			
		ES			x		RD 1085/2024 provides a more structured but demanding framework. The involvement of multiple authorities still causes delays. Regional "one-stop-shop" units could speed up the process.
	7.2. Complex permitting process	BG	X				
		DE				x	To declare the end-of-waste status according to the Fertilizing Product Regulation (2019/1009), a certification process of recovered fertilizers is needed. This process is very complex and costly. In Germany, there is no institution yet which offers to conduct the certification process.

		EL			x		
		IT			x		
		FR		X			
		ES	x				
	7.3. High permitting costs	BG	X				
		DE				x	See above
		EL		x			
		IT		x			
		FR	X				
		ES		x			Although the RD clarifies procedures, cost remains an issue for smaller projects. Public subsidies should cover risk plan development and monitoring costs.
	7.4. Political influence	BG	X				
		DE	X				Not likely, since P recovery in Germany is mandatory soon for many WWTPs.
		EL		x			
		IT	X				
		FR		X			
		ES	x				

ANNEX VI: Detailed driver of the ROps

Table 16: Comparison of the identified drivers by the ROps and the WS held at the GA in Bologna.

Driver	Validated in ROps	Validation from Country Texts
Environment		
Water scarcity or drought	France, Greece, Italy, Spain, WS	**France:** Droughts and water stress **Greece:** Water scarcity and prolonged droughts **Italy:** Severe environmental pressures, particularly droughts, act as the most potent catalyst for WACE adoption. **Spain:** Frequent droughts and increasing water scarcity. **WS:** National / regional targets (river basin)
Aquifer depletion and pollution (e.g. avoiding pollution discharges, saline intrusion)	-	-
Reducing demand for freshwater sources and replenishing natural resources	-	-
Climate-related challenges to water supply	France, Greece, Italy	**France:** Droughts, water stress (climate-driven) **Greece:** Impacts of climate change e.g. increasing pressure on water resources **Italy:** Severe environmental pressures, particularly droughts
Seasonal (e.g. emergency) and long-term water storage	-	-
Phosphorous capture and prevention of mineral fertiliser extraction	Germany	**Germany:** Mandatory in AbfKlärV" & "N/P recovery integrated in WWT process
Reduction of water, energy and carbon footprint in food and agricultural production (e.g. fertiliser saving, increased crop yield)	-	-
Improvement of marginal land for environmental or recreational uses	-	-
Spatial		
Proximity of treatment facilities to agricultural areas	-	-
Proximity between companies and industries fosters industrial symbiosis	-	-
Land development as an opportunity for new synergies and territorial cooperation	-	-
Financial		
Access to financing and cost allocation (e.g. synergies with international funding programmes)	Italy, Spain, WS	**Italy:** Enhanced access to funding **Spain:** EU funding for water-related innovation (LIFE, Horizon, PERTE) **WS:** Subsidies to make CE products competitive with the primary products
Lower input and operational costs and increased revenues (e.g. from nutrient recovery and biomass production)	Greece, Italy, WS	**Greece:** Reuse could reduce operational costs for industries **Italy:** Economic opportunities and significant cost savings recovery of valuable resources.

		WS: Incentives to attract new companies based on circular water economy (e.g. tax incentives in the early years) **WS:** No tax on reclaimed water supply for customers/consumers
Avoided cost of freshwater pumping and energy savings (e.g. less energy required than importing water or desalination)	WS	
Higher agricultural intensity with additional employment	WS	**WS:** Financial support to pioneers who first adopt and apply solutions
Value of ecosystem services and carbon credits (e.g. carbon tax implications for water pricing)	-	-
Technological		
Availability of technically feasible treatment solutions (e.g. good performance in removal of critical parameters in municipal secondary effluents)	-	-
Commercial use of by-products after treatment	Germany	**Germany:** Recovered N/P as substitute to continue circular model in the region
Obsolete water infrastructure failing to provide water security and in need of investment	-	-
Social		
High social value attributed to freshwater	Bulgaria	**Bulgaria:** Social pressure for a better environment (reflects high value placed on freshwater)
Public awareness of water resource management	Bulgaria, France, Italy	**Bulgaria:** Social pressure for a better environment **France:** Public awareness of water issues, pressure on asset managers and elected officials to act **Italy:** Build public support, making WACE indispensable
Information dissemination to promote public trust	-	-
Corporate sustainability focus	-	-
Experience with alternative water sources	-	-
Increasing water demand due to urbanisation, industrialisation and agriculture	-	-
Policy planning, regulatory and governance		
Support from regulators, politicians and public representatives	France, Italy	**France:** Political will **Italy:** Strong political will and robust stakeholder engagement **WS:** Standardisation and end of waste criteria, standardise the criteria for quality of CE products from circular waste sector, regulations that make circularity compulsory
Strict wastewater quality discharge regulations	Germany, WS	**Germany:** New UWWTD with stricter effluent limits **WS:** New UWWTD
Strong and well-established non-potable quality standards	WS	**WS:** Agreement on Quality Criteria for CE Products → e.g. CWA standards, Harmonised standards

Possibility to lower water quality requirements	-	-
Regulations enabling water reuse to support urban development	-	-
Flexible policy instruments enabling international convergence on best practice		-
Incorporation of public values into local and regional policies and planning	Italy	**Italy:** Holistic strategic framework and integrating circular economy principles into regional planning
Inclusion of reuse schemes in long-term strategic planning	Italy	**Italy:** Transforming the vision of a circular water economy into concrete regional action
Performance-based policies and regulations to encourage and reward environmental improvements	-	-
Fulfilment of water and environmental policy objectives (e.g. ecological protection and enhancement)	WS	**WS:** Evidence-based policy: Update regulations based on research data, national/regional targets
Coordinated support from local, regional and national government levels	Italy, WS	**Italy:** Permanent coordination bodies and active stakeholder networks. **WS:** Transboundary agreements
Governance structures encouraging cross-sectoral integration and interdepartmental coordination	Italy	**Italy:** Cooperation across sectors like water, energy, resource recovery
Clear and functional administrative frameworks regulating water use and reuse	Italy	**Italy:** Permanent coordination bodies and active stakeholder networks.
Strong private sector involvement	Germany, WS	**Germany:** Established cooperation between WWTP and farmers, motivation of utility to continue circular model **WS:** PPPs
Maintenance of trust between stakeholder groups	Germany	- **Germany:** Trust and collaboration are good (Braunschweig model)
Well-designed and implemented communication campaigns	WS	**WS:** Promote future vision and successful stories/projects, awareness and capacity building
Improved awareness, knowledge and capabilities (e.g. public openness to alternative water qualities)	WS	**WS:** Awareness and capacity building, Promote future vision and successful stories/projects
Mutual understanding of expectations regarding water quality and risk perception	WS	**WS:** Better, more comprehensive risk assessment guidance for the regulation on water reuse

ANNEX VII: Drivers, enabling factors and barriers connected

Summarised overview of regional enablers, drivers and barriers connected with the identified WACES barriers.

Table 17: Summary table of ROp specific enabling factors, drivers and barriers combined with the barriers identified by the WACES holders.

Category	Regional enablers	Regional drivers	Regional barriers	WACES barriers
Technical	- Existence of advanced recovery technologies enabling by-product valorisation (DE) - Technical know-how and expertise (EL, FR) - Technical innovation, digitalisation, and research capacity (IT) - Active research institutions and knowledge transfer hubs (ES)	- Pressure to adopt nutrient recovery technologies producing "ready-to-use" fertilisers (DE) - Industrial reuse and internal recycling reduce operational water demand (IT)	- Lack of modern solutions for mining pollutants (BG) - Space and infrastructure constraints (BG) - Insufficient tertiary treatment (EL) - Missing distribution systems (ES) - Lack of treatment/delivery infrastructure (FR) - Logistics challenges (DE) - Lack of technical training/capacity (ES, DE) - Monitoring tools imprecise and unsuitable for real-time control (IT) - Recovered fertilisers have unbalanced nutrient ratios (DE) - Struvite granulation quality issues limit application (DE)	- Remote areas requiring additional measures; unsatisfactory water quality requiring extra treatment and infrastructure - Environmental Technology Verification only certifies specific technologies - Module incompatibility and calibration need complicate operation - Land requirements and difficult integration with existing infrastructure - Continuous adaptations and need for large infrastructure and planning - Complex technologies need skilled staff; knowledge gaps take time to close - Doubts about long-term viability of materials - Lack of pollutant assessments, uncertain performance under regulations, need for LCAs - Handling dangerous goods (e.g. biogas) - Influent water quality unsuitable in some cases; persistent contaminants; cooling needs; dependence on upstream quality
Economic / Financial	- Subsidies for CE products (ES, WS) - Tax exemptions for reuse (WS) - Own investments by mining companies (BG) - Access to funding and financing instruments, including EU programmes (Life, Horizon) (BG, EL, IT, ES)	- Reduced operational costs & new revenue streams (GR, IT) - Incentives for companies (WS) - Fertiliser price shocks increase farmer interest in alternatives (DE)	- High investment needs requiring co-financing (BG, ES, EL, IT) - Low fertiliser market values (DE) - Lack of standardised pricing for reused water (DE, EL, FR) - Low water prices without cost recovery	- No standardised pricing system; unclear cost allocation - Economic uncertainty due to high monitoring costs and complex setups - Market demand low since reclaimed water is more expensive than potable or river water - Water utilities hesitant to adopt due to risks - Lack of research and optimisation funding at regional/local levels

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	- Corporate investments in reuse and efficiency programmes (IT)		- Limited research funding (DE, EL, FR, IT) - Low financial attractiveness & uncertainty (BG, ES, DE, FR, EL) - Long payback periods (BG, ES) - Reliance on large fertilizer supply markets (DE) - Bureaucracy hinders access to EU/national funding (IT)	- Higher costs of innovative developments and long payback periods - Dependence on EU subsidies with co-funding requirements
Social	- Awareness campaigns & capacity building (BG, IT) - Communication & success stories build trust (WS) - Openness of farmers and agricultural cooperatives to apply recovered fertilisers/innovation (DE, ES) - Positive branding and public engagement (FR) - Long tradition of water reuse fosters social acceptance (DE, IT) - Corporate stakeholder workshops and benchmarking enhance awareness (IT)	- High social value of freshwater (BG, IT) - Environmental awareness that put pressure on decision-makers (BG, IT) - Improved guidance for water reuse regulation (WS) - Peer pressure from frontrunner regions (Murcia in Spain) drives adoption (ES)	- Public distrust about safety (BG, ES) - Farmer refuse reclaimed fertilizer due to nutrient variability (DE) - Critical views of WACE projects in general (FR) - "Dirty water" perception (ES) - Public "yuck factor" limits acceptance (IT) - Farmers distrust reclaimed water quality (ES) - Low public awareness of nutrient recycling (DE)	- Fear of consumer rejection of irrigated products - Expectations about certification standards for social acceptance - Associations with smell or dangerous goods - Concerns about impacts on tourism - Stakeholder conflicts and inadequate community engagement - Lack of available information - Spread of misinformation and mistrust of stakeholders
Political	- Regulatory & political support (FR, IT) - Standardisation/end-of-waste criteria (WS) - Clear strategic planning (IT) - Strategic alignment with national and EU circular economy policies (IT)	- Political will (FR) - Stakeholder engagement (IT) - Droughts & water scarcity as catalyst (FR, EL, IT, ES) - Climate change increasing water stress (FR, EL, IT) - Policy integration (IT) - Evidence-based policymaking (WS)	- Lack of CE water frameworks (BG) - Wastewater law rigidity (DE) - Partial integration of water reuse in policies (EL) - Lack of long-term planning (BG, EL, FR, ES) - Short term crisis management (EL, FR, ES)	- Absence of CE frameworks or fragmented ones - Politicians lacking knowledge or trust in innovative solutions - Political focus on traditional designs - Administrative and procurement challenges delaying innovation uptake - Poor understanding of stakeholder needs and diverging regional interpretations - Rigid and inflexible political structures and regulations

	- Existence of a WACES-supportive narrative in regional strategies (ES) - Participation in international initiatives (IT) - Regional funding for reuse infrastructure (IT)	- Coordination across levels of government and sectors (IT) - Public-private partnerships (DE, WS) - Provision of support from regulators, politicians and public representatives - Corporate water stewardship certifications (AWS) drive engagement (IT)	- Knowledge gaps among politicians (DE, ES) - Regional government slow in addressing water scarcity (ES)	
Institutional	- Coordination mechanisms between authorities & sectors (IT) - Cross-sectoral integration (IT) - Improved cooperation among water supply and sewerage operators (BG) - Established cooperation between WWTPs and farmers (e.g. Braunschweig model) (DE) - Motivation of WWTP utilities to maintain the circular model (DE) - Strong regional cooperation and stakeholder networks (IT) - Integration across sectors (water, energy, resources) (IT)	-	- Lack of coordination & overlapping responsibilities on different policy levels (BG, ES) - Limited institutional support (EL, ES) - Weak maintenance and leakage issues in regional networks (ES)	- Unclear roles and responsibilities, fragmented regulation - Overlapping jurisdictions and decentralised structures - Institutional knowledge gaps (e.g. microbial safety, Legionella) - Authorities working in silos and lack of accountability - Rigid two-step authorisation procedures and result-oriented tenders missing - Conservative administrations prefer conventional solutions - Lack of clear political support and funding mechanisms - Strict procurement rules and tendering requirements hinder innovation - Short-term perspectives of institutions and lack of motivation among operators
Regulatory/ Legal	- Harmonization of standards (WS) e.g.: - EU Water Reuse Regulation (WS) - EU Fertiliser Product Regulation (WS) - Long-term planning (IT)	- UWWTD revision: stricter effluent limits (DE, WS) - Stronger non-potable standards (DE, WS) - National P-recovery obligations (DE) stimulate innovation	- Lack of harmonised standards/guidance (DE, IT, ES, FR) - Inflexible frameworks (DE, FR) - Complex monitoring (DE, FR, ES) - Complexity of implementing new EU directive on agricultural reuse (IT)	- Lack of certification standards and inflexible frameworks - National variations in rules limit replication - EU-level authorisations create uncertainty - Lack of harmonised standards for integrated water cycle approaches - Varying certification procedures across countries - Missing or unclear standards for methods and definitions

	- Irrigation consortia coordinate seasonal water needs with farmers (IT)			- Preference for lab analysis over online monitoring - Some technologies not included in legislation - Limited guidance for integration into reuse schemes - Unclear ownership of treated wastewater and energy - Confusing or evolving rules delay approvals - Lack of clarity on agricultural product safety
Permitting	- Clearer administrative frameworks improving stability (IT) - Simplified permitting (IT)	-	- Slow/inconsistent permitting (BG) - Costly certification under EU FPR (DE) - Missing protocols & risk interpretation issues (FR) - Multi-authority permitting demanding/costly (ES)	- Lengthy and bureaucratic permitting processes delay uptake - Institutional bottlenecks with few organisations able to certify components - High permitting costs - Multiple permits required - Too many or unclear requirements in some contexts

The quantity and quality of water resources are serious problems in many European areas, mostly being a joined result of climate change and anthropic influences. The BOOST-IN project aims to develop a successful strategy that promotes technological changes, governance schemes, shifts in mind-set and organizational structures to solve these problems through a better management of the water sector and application of the circular economy principles, enabling water reuse and recovery of different materials (e.g. energy, nutrients). However, implementation of these changes still faces several barriers (e.g. technology, economy, knowledge, social perception) that need to be overcome. BOOST-IN will achieve these goals by an effective identification, selection (through a specifically designed dynamic funnel method) and transfer of innovative Water Circular Economy Solutions (WACES) to further close and improve the water cycle.

The project will develop and apply its approach in six Regions of Opportunity evenly distributed across Europe (Spain, Greece, Germany, France, Italy and Bulgaria) by organization of co-creation workshops to increase public awareness and support for WACES implementation, barriers overcoming as well as by the specific risk management plans design.

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