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Wastewater Treatment in Italy: From Cost Centre to Strategic Investment

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Abstract

Urban wastewater treatment has traditionally been framed as a regulatory obligation and a cost centre required to comply with environmental standards and mitigate the impact of discharges on aquatic ecosystems. However, in the context of increasing water scarcity, climate-related risks, and the broader ecological transition, this perspective is evolving. Wastewater is increasingly recognised not merely as waste to be disposed of, but as a potential strategic resource capable of generating environmental, economic, and social value. This study examines whether and to what extent wastewater treatment can be reframed as a strategic investment rather than a purely defensive environmental cost. The analysis adopts a structured qualitative policy-analysis approach, combining documentary analysis of European and Italian regulatory frameworks with quantitative evidence derived from institutional indicators and secondary data from international organisations. In addition, illustrative evidence on water reuse, energy recovery, and nutrient recovery is used to assess the contribution of wastewater treatment to circular economy processes. The research addresses three main questions: (RQ1) whether investments in wastewater treatment generate economic and social returns; (RQ2) how wastewater treatment contributes to circular economy dynamics through resource recovery; and (RQ3) what economic and environmental costs may arise from delayed or insufficient intervention, including regulatory sanctions, environmental damage, and the loss of recoverable resources. The findings suggest that investments in wastewater treatment can generate significant socio-economic benefits, particularly when

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treatment infrastructures enable water reuse, energy recovery, and resource valorisation. The analysis also highlights that delayed investment may produce substantial economic and environmental costs, reinforcing the relevance of the "cost of inaction" perspective. Finally, the study underscores the importance of integrated governance frameworks and long-term planning strategies, with particular attention to Southern Italy, where infrastructural gaps continue to generate environmental pressures and economic inefficiencies.

Keywords: Wastewater treatment; Circular economy; Strategic investment; Water reuse; Italy

1. Introduction

Urban wastewater management represents a fundamental yet often invisible component of modern urban systems. As long as treatment infrastructures operate effectively, their role tends to remain unnoticed; however, when failures occur, the consequences rapidly become evident through environmental degradation, public health risks, deterioration in quality of life, and reputational damage for affected territories. Despite this strategic relevance, wastewater treatment has frequently been framed within a narrow regulatory perspective, primarily as a compliance-driven activity aimed at meeting environmental standards and avoiding legal sanctions.

Within this perspective, purification infrastructures have often been interpreted as a necessary cost rather than as a strategic investment. As a result, public expenditure in this sector has frequently been postponed or limited, particularly within short-term political and budgetary cycles. In the Italian context, this approach has contributed to the persistence of infrastructural gaps, fragmented governance arrangements, and repeated infringement procedures initiated by European institutions. A significant example is the 2018 ruling of the Court of Justice of the European Union, which imposed a lump-sum fine of €25 million on Italy, together with periodic penalties exceeding €30 million for each six-month delay in complying with obligations concerning wastewater treatment agglomerations already subject to a previous judgment (Court of Justice of the European Union, 2018). Subsequent rulings and sanctions suggest that the issue cannot be considered episodic, but rather reflects structural weaknesses in infrastructure development and management.

At the same time, the broader environmental and policy context has undergone significant transformation. Increasing water scarcity, more frequent drought episodes, and climate-related pressures have intensified competition among civil, agricultural, and industrial water uses. In response, the European Union has progressively strengthened its environmental policy framework, promoting circular economy models that emphasise pollution

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reduction, resource efficiency, and the recovery and reuse of water, materials, and energy.

Within this evolving context, wastewater treatment can no longer be interpreted solely as a downstream process aimed at complying with regulatory discharge limits. Instead, it can be increasingly understood as an enabling platform for circular economy practices. Treated wastewater may represent a reusable resource for agriculture or industry, sewage sludge can serve as a potential energy source, and nutrients recovered during treatment processes may be reintroduced into productive cycles as secondary raw materials. Consequently, the sector appears to be gradually shifting from a defensive paradigm – focused on minimising regulatory risk – towards a more proactive perspective in which environmental infrastructure contributes to economic value creation, territorial resilience, and long-term sustainability.

Building on these premises, this study investigates whether wastewater treatment can be reframed as a strategic investment rather than merely as a regulatory cost. In particular, the analysis focuses on the Italian context, where infrastructural deficits have historically contributed to persistent environmental pressures, economic inefficiencies, and territorial disparities, especially in Southern regions. The objective of the study is therefore to assess the potential environmental, economic, and governance implications associated with a more strategic interpretation of wastewater treatment investments.

While the regulatory and technical dimensions of wastewater treatment have been widely discussed, less attention has been devoted to its interpretation as a strategic investment at the intersection of environmental governance, circular economy, and territorial development. This study contributes to the existing literature by providing an integrated policy-oriented analysis that combines documentary evidence, quantitative institutional data, and selected academic contributions to examine wastewater treatment not only as an environmental obligation, but as a strategic infrastructure with broader socio-economic implications. In doing so, it aims to address a gap in the literature concerning the economic and governance dimensions of wastewater management within the framework of circular economy and sustainable territorial development.

2. Context

2.1. The European framework: from environmental compliance to circular transition

The European regulatory framework governing urban wastewater treatment has historically been shaped by Directive 91/271/EEC, which established the basic requirements for the collection and treatment of urban wastewater with the primary objective of protecting aquatic ecosystems and

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public health. For several decades, the directive has represented the cornerstone of European environmental policy in the water sector, focusing primarily on ensuring compliance with minimum treatment standards and reducing the environmental impacts of untreated or insufficiently treated discharges.

In recent years, however, the European policy trajectory has progressively evolved beyond a purely compliance-oriented approach. Wastewater management is increasingly integrated into broader strategies related to climate mitigation, resource efficiency, and circular economy principles. This evolution is reflected in the recast Directive (EU) 2024/3019, which introduces new provisions aimed at strengthening environmental performance, improving energy efficiency, and promoting resource recovery within wastewater treatment systems (European Parliament and Council of the European Union, 2024). In particular, the directive outlines a progressive pathway towards the energy neutrality of treatment plants and places greater emphasis on emerging pollutants, including micropollutants, alongside the introduction of extended producer responsibility mechanisms for specific industrial sectors.

These regulatory developments suggest a broader conceptual shift. Wastewater treatment plants are no longer viewed exclusively as infrastructures designed to mitigate environmental damage, but can increasingly be interpreted as technological platforms potentially contributing to resource recovery, energy production, and emission reduction within integrated environmental systems.

A further key component of the European regulatory framework is Regulation (EU) 2020/741 on minimum requirements for water reuse. The regulation establishes harmonised standards for the safe reuse of treated wastewater in agricultural irrigation, defining technical requirements, risk management procedures, and responsibilities for operators and authorities (European Parliament and Council of the European Union, 2020). This regulatory initiative forms part of a wider European strategy aimed at promoting more sustainable and integrated water resource management, particularly in regions exposed to structural water scarcity.

Within this evolving policy context, water reuse can no longer be considered merely a marginal practice. In territories characterised by persistent water stress, the underutilisation of treated wastewater may lead to significant environmental, economic, and territorial inefficiencies over the long term.

2.2. Necessary investments and “cost of inaction” risk

An often underestimated dimension of wastewater policy concerns the economic scale of the investments required to achieve and maintain regulatory

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compliance. According to estimates frequently cited by the European Commission and based on OECD analyses, additional investments amounting to several hundred billion euros may be required across Europe between 2020 and 2030 to support the full implementation and long-term sustainability of wastewater treatment systems (European Commission, 2020).

At first glance, these figures may appear to reinforce the perception of wastewater infrastructure as an excessively costly sector. However, the economic debate increasingly emphasises an alternative perspective: the cost of inaction. Delayed investments in wastewater infrastructure not only perpetuate environmental risks but may also generate substantial financial penalties and long-term inefficiencies.

The Italian case provides a particularly illustrative example. In 2018, the Court of Justice of the European Union imposed a lump-sum fine of €25 million on Italy, together with periodic penalties exceeding €30 million for each six-month period of delay in complying with obligations concerning wastewater treatment agglomerations already subject to a previous judgment (Case C-251/17) (Court of Justice of the European Union, 2018). Subsequent rulings and ongoing infringement procedures suggest that non-compliance remains a persistent structural issue.

Available institutional evidence indicates that these compliance gaps remain geographically concentrated, particularly in several regions of Southern Italy. This infrastructural deficit not only generates environmental pressures and financial sanctions, but may also contribute to broader territorial disparities, reinforcing structural differences in development, investment capacity, and environmental quality (Ministry of the Environment and Energy Security, n.d.).

3. Methodology

The study adopts a structured qualitative policy-analysis approach, supported by selected quantitative evidence, with the aim of examining whether wastewater treatment can be interpreted not only as a compliance-driven environmental service, but also as a strategic investment capable of generating environmental, economic, and social value. The analytical framework is informed by a cost-of-inaction perspective, which allows for a conceptual evaluation of both the potential benefits of investment and the economic and environmental implications associated with delayed or insufficient intervention.

The methodological design integrates three complementary analytical components. First, a documentary and regulatory analysis of the European institutional framework governing urban wastewater management was conducted. This includes European directives and regulations, reports of the European Commission, sectoral evaluation documents, and rulings of the

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Court of Justice of the European Union. These sources were selected to reconstruct the evolution of wastewater governance and to identify key policy orientations related to environmental protection, circular economy transition, and resource recovery.

Second, the study incorporates quantitative evidence derived from comparable international and institutional sources. This includes OECD estimates concerning the scale of investments required to support wastewater treatment systems, as well as cost–benefit indications of water and sanitation investments reported in institutional and academic literature. These data are not used for direct empirical testing, but rather to support and contextualise the analytical interpretation of the economic and social implications associated with wastewater infrastructure.

Third, a targeted literature review was conducted using the Scopus database in order to support the academic positioning of the study. The search was performed using the query TITLE-ABS-KEY (wastewater AND ("circular economy" OR "water reuse" OR "resource recovery" OR "wastewater treatment")), limited to the period 2023–2026 and restricted to peer-reviewed articles and reviews in English. The search was further filtered by subject area (Business, Management and Accounting) to focus on governance, strategic management, and economic evaluation perspectives. The initial query returned 24 documents; following a screening process based on thematic relevance and alignment with the research focus, four contributions were selected to complement the analysis. While limited in scope, this targeted review provides a focused overview of recent academic contributions relevant to the research questions.

The analytical process follows a structured sequence: (i) identification and selection of sources, (ii) categorisation of evidence according to the three analytical dimensions (economic returns, circular economy contribution, and cost of inaction), and (iii) synthesis and interpretation of findings in relation to the research questions. The integration of documentary evidence, institutional data, and selected academic contributions enables a multi-dimensional interpretation of wastewater treatment within a policy-oriented framework.

The analysis is guided by three research questions: (RQ1) whether investments in wastewater treatment may generate economic and social returns; (RQ2) to what extent wastewater treatment can contribute to circular economy processes through the recovery of water, energy, and nutrients; and (RQ3) what economic, environmental, and institutional implications may arise from delayed or insufficient investments in wastewater infrastructure.

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4. Results

4.1. Economic benefits of wastewater treatment investments

The first analytical finding concerns the economic value associated with investments in wastewater treatment. Although purification infrastructure is often framed primarily as a regulatory cost, the analysis suggests that the associated benefits extend beyond the direct financial dimension. In this context, the notion of "return" should be interpreted in a broader socio-economic sense, encompassing health-related improvements, productivity gains, environmental benefits, and long-term territorial resilience.

Existing evidence on water and sanitation investments highlights significant benefit–cost relationships. In particular, widely cited estimates indicate that the global benefit–cost ratio for sanitation investments may reach approximately 5.5 dollars for every dollar invested, when reductions in disease incidence, productivity gains, and wider social benefits are taken into account (Hutton & Varughese, 2013). These figures should not be interpreted as precise predictive values, but rather as indicative of the magnitude of the externalities associated with water infrastructure. In this perspective, the underinvestment in wastewater treatment systems may generate indirect costs that re-emerge in the form of environmental degradation, public health risks, and economic losses.

The evidence summarised in Table 1 supports this interpretation by highlighting a set of indicative economic dimensions associated with the water sector. Rather than representing precise and directly comparable estimates, these values provide an aggregated overview of the potential scale of economic and social impacts linked to wastewater-related investments.

At the macroeconomic level, the water sector appears to play a relevant role in national economies. Recent sectoral reports for Italy indicate that the extended water supply chain contributes to the activation of economic value and employment effects, both directly and indirectly (The European House – Ambrosetti et al., 2025).

Overall, the analysis suggests that investments in wastewater infrastructure may contribute not only to environmental protection but also to economic activity, technological development, and employment generation, thereby reinforcing the strategic relevance of the sector within sustainable development policies.

Table 1: Items and estimated values

Item	Estimated value
Health benefits and productivity (WHO)	€5.5 benefit for every €1 invested
Net benefits of water investments in Italy (to 2050)	≈ €3.1 billion
Added value of the water service	€16.5 billion per year
Employment generated	>150,000 employees

Source: Author's elaboration based on institutional and secondary data

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4.2. Wastewater treatment and circular economy potential

The second analytical finding concerns the role of wastewater treatment within circular economy strategies. Modern treatment plants can increasingly be interpreted not as linear infrastructures based on the traditional collect–treat–discharge model, but as platforms enabling resource recovery and circular resource flows.

Recent academic contributions suggest that wastewater treatment systems may contribute to circular economy dynamics through the recovery of water, energy, and nutrients (Smol et al., 2025; Bhambhani et al., 2025). In particular, treated wastewater can represent a relevant alternative water resource in regions exposed to increasing water scarcity.

Despite this potential, water reuse remains relatively limited in Europe. European Commission estimates indicate that a substantial share of treated wastewater could be reused for irrigation or industrial purposes, particularly in regions experiencing structural water stress (European Commission, n.d.). In the Italian context, sectoral analyses point to a significant gap between the potential availability of reclaimed water and its actual use (Legambiente, 2023). International benchmarks further suggest that higher reuse levels are technically feasible. For example, in Israel approximately 90% of treated wastewater is reused, particularly in agricultural irrigation systems (U.S. Environmental Protection Agency, 2023).

Beyond water reuse, wastewater treatment plants also offer opportunities for energy recovery and resource valorisation. The wastewater sector is energy intensive: the European Commission estimates that wastewater treatment accounts for approximately 0.8% of total energy consumption in the European Union (European Commission, 2019). However, this also implies a relevant potential for energy recovery through processes such as anaerobic digestion and biogas production. The recast Directive (EU) 2024/3019 further reinforces this orientation by introducing progressive targets for energy neutrality and improved environmental performance in wastewater treatment plants (European Parliament and Council of the European Union, 2024).

A third circular economy pathway concerns nutrient recovery. Phosphorus contained in wastewater represents a potentially valuable secondary raw material. Existing estimates suggest that the recovery of nutrients from human waste streams could contribute to covering a significant share of global phosphorus demand, highlighting the potential strategic relevance of wastewater systems for future resource security (Mihelcic et al., 2011).

The evidence summarised in Table 2 highlights the existence of a gap between the current utilisation of wastewater-derived resources and their estimated potential. Rather than providing precise quantitative measurements,

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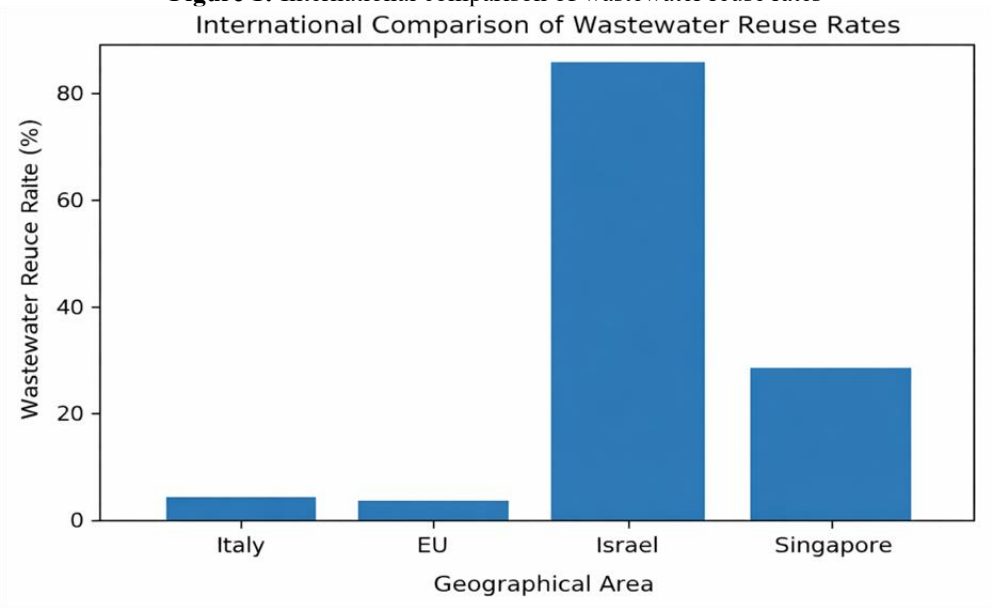
these data offer an indicative overview of underexploited opportunities in water reuse, energy recovery, and nutrient valorisation. Overall, the analysis suggests that these dimensions remain only partially developed, despite their potential contribution to water security, energy efficiency, and agricultural sustainability.

Figure 1: International comparison of wastewater reuse rates



Source: Author's elaboration based on institutional data

Figure 1 provides a comparative overview of wastewater reuse rates across selected geographical contexts, highlighting significant differences between European countries and international benchmarks. In particular, the figure shows that wastewater reuse in Italy and the European Union remains relatively limited, especially when compared to countries such as Israel and Singapore, where reuse practices are more extensively developed. Rather than representing strictly comparable values across identical regulatory and infrastructural conditions, the data illustrated in the figure should be interpreted as indicative of different levels of policy prioritisation, technological adoption, and governance effectiveness in wastewater reuse. In this sense, the comparison highlights the existence of a substantial gap between current practices in Europe and the levels achieved in contexts where reuse has been strategically integrated into water management systems.

Overall, the figure suggests the presence of significant unrealised potential associated with the expansion of wastewater reuse, particularly in countries characterised by increasing water stress and infrastructural constraints.

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Table 2: Estimated potential

Scope	Current situation	Estimated potential
Wastewater reuse (Italy)	≈ 4%	≈ 23–45% of irrigation demand
Wastewater reuse (EU)	≈ 2.4%	≈ 15–20% of treated volumes
Energy production from sludge (Italy)	Limited	≈ 2 TWh per year
Phosphorus recovery (global)	Marginal	≈ 22% of global demand

Source: Author's elaboration based on institutional and secondary data

The values reported in Table 2 provide an indicative overview of the gap between current utilisation levels and the estimated potential of wastewater-related resources. These figures are derived from a combination of institutional reports and secondary sources and are not intended as directly comparable or predictive estimates.

Rather, they serve to illustrate the magnitude of underexploited opportunities associated with wastewater reuse, energy recovery, and nutrient valorisation. The comparison between current conditions and estimated potential suggests that wastewater systems remain only partially utilised as strategic assets within circular economy frameworks.

4.3. The economic and environmental costs of non-intervention

The third analytical finding concerns the economic and environmental implications associated with delayed or insufficient investment in wastewater infrastructure. If investments in this sector are associated with potential socio-economic benefits, the absence or postponement of such investments may generate corresponding economic and environmental costs.

In the Italian case, these costs are partly observable through financial sanctions imposed by European institutions. The ruling of the Court of Justice of the European Union in Case C-251/17 imposed a lump-sum fine together with periodic penalties for non-compliance with wastewater treatment obligations (Court of Justice of the European Union, 2018). Subsequent rulings and ongoing infringement procedures suggest that non-compliance remains a persistent structural issue. In practical terms, insufficient investment in infrastructure may translate into recurrent financial penalties, which represent a redistributive cost rather than a productive allocation of resources.

However, the cost of non-intervention extends beyond direct sanctions. Environmental and health impacts generate broader external costs that are more difficult to quantify but remain highly relevant. For instance, European studies on reactive nitrogen pollution estimate total damages ranging from tens to hundreds of billions of euros annually across the European Union (Sutton et al., 2011). While wastewater treatment represents only one component of the broader nitrogen cycle, inadequate treatment may contribute to eutrophication, biodiversity loss, and increased water purification costs.

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A further dimension concerns the loss of recoverable resources. Each cubic metre of treated wastewater that is not reused, each unit of nutrients that is not recovered, and each potential unit of energy that is not generated from sludge can be interpreted as a missed opportunity for resource valorisation. This situation may entail a double economic implication: the foregone value of recoverable resources and the continued reliance on alternative and often more costly supply systems.

The data summarised in Table 3 provides an indicative overview of the order of magnitude of the direct and indirect costs associated with delayed intervention. Rather than representing precise or fully comparable estimates, these values highlight how non-investment may generate recurrent financial burdens and broader environmental externalities, rather than actual savings.

Table 3: Cost magnitudes

Cost item	Order of magnitude
EU fines already paid by Italy	> €200 million
Ongoing six-monthly penalties	> €30 million per six-month period
Reactive nitrogen damage in the EU	€70–320 billion per year
Non-compliant Italian agglomerations	> 900

Source: Author's elaboration based on institutional and secondary data

5. Implications and conclusions

Recognizing wastewater treatment as a productive investment rather than merely as a regulatory obligation carries relevant implications for public policy design and infrastructure planning. The findings of this study suggest that wastewater management should not be interpreted solely through the lens of environmental compliance, but can be understood as a strategic component of sustainable development policies. In this perspective, purification infrastructure assumes a structural role within water governance systems, contributing to environmental protection, economic development, and resource security.

One of the main implications concerns the scale and planning of investments. The magnitude of the infrastructural adjustments required suggests that episodic or reactive policy interventions are unlikely to be sufficient. Policies based on short-term responses or fragmented decision-making may not effectively address existing infrastructural gaps or ensure stable service standards over time. Instead, long-term planning frameworks appear necessary, supported by transparent prioritisation criteria and analytical tools such as cost–benefit analysis. These evaluations should incorporate not only construction and operational costs, but also broader environmental, health, and economic implications, including water quality improvements, reduced public health risks, and resource recovery potential.

Beyond financial resources, the effectiveness of wastewater investments is closely related to governance quality and managerial capacity.

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Fragmentation of service management, which still characterises several areas of the Italian territory, is often associated with lower investment capacity, operational inefficiencies, and uneven service quality. The transformation of wastewater treatment plants into circular economy platforms may therefore require more integrated governance structures, stronger coordination mechanisms, and regulatory frameworks capable of incentivising efficiency, innovation, and performance monitoring.

These considerations are particularly relevant from a territorial perspective. In several regions of Southern Italy, infrastructural deficits in wastewater treatment remain more pronounced. In such contexts, the cost of non-intervention may manifest through multiple channels, including European infringement procedures, environmental degradation, reduced tourism attractiveness, and constraints on agricultural development. From this perspective, investments in wastewater infrastructure can be interpreted as structural interventions potentially capable of mitigating the link between infrastructural deficiencies, economic penalties, and territorial disparities.

This study contributes to the literature by providing an integrated policy-oriented assessment of wastewater treatment as a strategic infrastructure, combining documentary analysis, institutional evidence, and selected academic contributions.

The findings allow a direct response to the research questions. With respect to RQ1, the analysis suggests that investments in wastewater treatment may generate economic and social returns, particularly when indirect effects such as health improvements, productivity gains, and environmental protection are considered. Regarding RQ2, the findings indicate that wastewater treatment can contribute to circular economy processes through water reuse, energy recovery, and nutrient recycling. With respect to RQ3, the analysis highlights that delayed or insufficient investments may generate economic and environmental implications, including financial sanctions, environmental degradation, and the loss of recoverable resources.

Taken together, these findings support the interpretation of wastewater treatment as a strategic infrastructure sector within sustainable development policies. In the context of increasing water scarcity and growing environmental pressures, treating wastewater solely as a waste management issue appears economically limiting and potentially short-sighted from a policy perspective.

At the same time, the study presents certain limitations. The analysis relies primarily on secondary data and institutional sources and does not include econometric modelling or primary empirical data collection. Future research could extend these findings through quantitative analyses of wastewater investment performance, more extensive literature reviews, or comparative case studies across different European regions.

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