

A Work Project, presented as part of the requirements for the Award of a Master's degree in Management/Impact Entrepreneurship and Innovation from the Nova School of Business and Economics.

Field Lab Project:

Consultancy - Águas Tejo: Integrating ESG Criteria into Corporate
Culture: Strategies, Challenges, and Impacts

Individual Focus:

Strengthening the Environmental Performance of Águas do Tejo Atlântico: A Deep Dive into
Priorities, Best Practices, and Regulatory Implications to Inform Strategic Decision Making

By

Giles Cook

Work project carried out under the supervision of:

Hugo Menino Aguiar

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Abstract – Group Section

Methods to incorporate Environmental, Social and Governance (ESG) criteria within the corporate culture and management systems of Águas do Tejo Atlântico, a water and waste management company, were analysed and presented through this project. Drawing from CSRD/ESRS and EU Taxonomy, internal documents and interviews, the study diagnoses governance gaps, KPI ownership, data reliability, and cross-sectional coordination. Suggestions for improvement include a board-level ESG committee, an integrated ESG dashboard, enhanced internal controls, and assurance mechanism improvements. Furthermore, it presents a roadmap to outline integration steps and aid in strategically embedding ESG into long-term decision-making, risk management, and stakeholder engagement at an operational level.

Abstract – Individual Section

A focus on strengthening the environmental performance of Águas do Tejo Atlântico by examining the four areas identified as strategic priorities; wastewater reuse, energy efficiency, biodiversity stewardship, and sludge valorisation. Through a review of academic literature, industry case studies, and key regulatory frameworks, namely Portugal's Decree-Law 119/2019 and the EU Water Framework Directive, best practices and regulatory implications are identified across each area. Findings reveal significant interdependencies between the four priorities, highlighting the need for an integrated, performance-based approach underpinned by unified KPIs, digital monitoring, and proactive stakeholder engagement, providing an evidence-based foundation for strategic decision making.

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Table of Contents

Abstract	1
Table of Contents	2
Abbreviation:	4
1. Introduction	7
1.1. ESG and Its Growing Relevance for Water Utilities	7
1.2. Context of Águas do Tejo Atlântico and Emerging Regulatory Pressures	7
1.3. The Fundamental Challenge: Embedding ESG into Corporate Culture and Improving Reporting	9
1.4. Project Scope, Methodology and Constraints	10
2. AdTA & Project Context	11
2.1. Overview of AdTA's Mission and Operations	11
2.2. Summary of Current ESG Position	12
Environmental	12
Social	13
Governance	14
2.3. Why ESG Integration Matters for AdTA	16
3. Governance as the Foundation	18
<i>The Impact of Regulatory Frameworks</i>	<i>18</i>
<i>Strategic Alignment</i>	<i>19</i>
<i>Risk Management in the Water Sector</i>	<i>19</i>
<i>The Value of Stakeholder Engagement</i>	<i>20</i>
<i>Role of governance in enabling Environmental & Social performance</i>	<i>20</i>
<i>KPI accountability</i>	<i>21</i>
4. Strategic Recommendations	22
4.1. Governance Priorities	22
Priority 1: Establish a dedicated ESG / Sustainability Committee	22
Priority 2: Design and embed an integrated ESG performance dashboard	23
Priority 3: Strengthen internal controls and external assurance over ESG information	23
4.2. Environmental Priorities	25

Group part

Priority 1: Embed Environmental and Social Metrics into Strategic and Financial Decision-Making through a Unified KPI Framework	25
Priority 2: Utilise Digital Tools to aid Environmental Monitoring and Reporting	25
Priority 3: Strengthen Internal Controls and Evidence Tracking	25
Priority 4: Strengthen Environmental Performance Through Strategic Partnerships and Stakeholder Engagement	26
Priority 5: Training and Cross-Functional Collaboration	26
4.3. Social Priorities	26
Priority 1: Supporting the Wellbeing & Safety of Our People	26
Priority 2: Improving Employee Engagement & ESG Education.....	27
Priority 3: DEI (Diversity, Equity and Inclusion)	27
Priority 4: Increase Community & Stakeholder Engagement.....	27
4.4. Cross-Pillar Roadmap for ESG Integration at AdTA.....	28
4.4i. Short-term actions (0–6 Months)	29
4.4ii. Mid-term actions (6-18 months).....	31
4.4iii. Long-term actions (18-36 months)	34
5. Conclusion	36
Strengthening the Environmental Performance of Águas do Tejo Atlântico: A Deep Dive into Priorities, Best Practices, and Regulatory Implications to Inform Strategic Decision Making	38
1. Introduction	38
2. Wastewater Reuse	38
Best Practices	40
<i>Strategic and Governance Requirements for Reuse Expansion</i>	<i>40</i>
<i>Monitoring, Indicators, and Operational Performance Management</i>	<i>40</i>
<i>Technological and Risk-Management Requirements</i>	<i>41</i>
<i>Cooperative and Social Acceptance</i>	<i>41</i>
3. Enhancing Energy Efficiency and the Transition to Clean Energy.....	42
Best Practices	42
<i>Benchmarking as the foundation</i>	<i>42</i>
<i>Indicators.....</i>	<i>43</i>
<i>Digitalisation and the enhancement of organisational capabilities.....</i>	<i>43</i>
4. Biodiversity and Ecosystem Stewardship.....	44

Best Practices	45
<i>Collaboration and the Need for a Systemic, Catchment-Scale Governance Approach</i>	45
<i>Outcome-Based Monitoring.....</i>	45
<i>Internal Controls, Transparency, and Engagement in Water Governance</i>	46
5. Sludge Valorisation and Circular Resource Pathways	46
Best Practices	47
<i>Biogas, Biomethane, and Circular Resource Management</i>	47
Agricultural Reuse as a Complementary Valorisation Strategy	48
<i>Safeguarding Public and Environmental Health Through Monitoring and Training</i>	48
6. Regulatory Implications for AdTA: Looking at Portugal's Decree-Law 119/2019 and the EU's Water Framework Directive to strengthen strategic recommendations ..	49
7. Conclusion.....	51
References/Bibliography	52

Keywords

ESG integration; CSRD/ESRS; Water utilities; Corporate governance; KPI dashboard; Sustainability reporting; Data governance; Stakeholder engagement

Abbreviations:

AdP	Águas de Portugal
AdTA	Águas do Tejo Atlântico
AdVT	Águas do Vale do Tejo
AI	Artificial Intelligence
APA	Agência Portuguesa do Ambiente
ApR	Água para Reutilização
BI	Business Intelligence
CAPEX	Capital Expenditures
CITE	Comissão para a Igualdade no Trabalho e no Emprego
CSR	Corporate Social Responsibility
CSRD	Corporate Sustainability Reporting Directive
CSRD/ESG	Corporate Sustainability Reporting Directive / Environmental, Social and Governance
CSRD/ESRS	Corporate Sustainability Reporting Directive / European Sustainability Reporting Standards
DEI	Diversity, Equity and Inclusion
E3	ESRS E3 (Water and Marine Resources)

Group part

EC	European Commission
EEA	European Environment Agency
EFRAG	European Financial Reporting Advisory Group
EPAL	Empresa Portuguesa das Águas Livres
EPI	Equipamento de Proteção Individual
ERM	Enterprise Risk Management
ERSAR	Entidade Reguladora dos Serviços de Águas e Resíduos
ESG	Environmental, Social and Governance
ESIC	Ethics, Sustainability and Inclusion Committee
ESRS	European Sustainability Reporting Standards
EU	European Union
G1	ESRS G1 (Business conduct)
GEP	Gender Equality Plan
GHG	Greenhouse Gases
GOV	ESRS 2 Governance disclosure requirements (GOV-1 to GOV-5)
GRI	Global Reporting Initiative
H&S	Health and Safety
HR	Human Resources
ICRMS	Internal Control and Risk Management System
ICSR	Internal Control over Sustainability Reporting
IEA	International Energy Agency
ILO	International Labour Organization
ISO	International Organization for Standardization
IUCN	International Union for Conservation of Nature
IWA	International Water Association
KPI	Key Performance Indicator
LIMS	Laboratory Information Management System
M&O	Maintenance and Operations
NGOs	Non-Governmental Organizations
NP	Norma Portuguesa
OECD	Organisation for Economic Co-operation and Development
OHS	Occupational Health and Safety
OPEX	Operating Expenditures
POR	Programa Operacional Regional
PPE	Personal Protective Equipment
RASARP	Relatório Anual dos Serviços de Águas e Resíduos em Portugal
RGPC	Regime Geral da Prevenção da Corrupção
ROI	Return on Investment
SCADA	Supervisory Control and Data Acquisition
SCIGR	Sistema di Controllo Interno e Gestione dei Rischi
SDGs	Sustainable Development Goals

Group part

UN United Nations
UNGC United Nations Global Compact
WFD Water Framework Directive

1. Introduction

1.1. ESG and Its Growing Relevance for Water Utilities

ESG integration is established as a characteristic of contemporary infrastructure management and the provision of public services. While its roots can be found in financial and corporate investment markets, ESG has become increasingly important for public sector utilities, including water and wastewater, in the last ten years. Water utilities are at the nexus of environmental stewardship, public health, community vitality and infrastructure governance for future generations, providing a bright spotlight on the pressures (and opportunities) ESG guidelines strive to influence.

The literature review reveals that ESG adoption positively contributes to financial and operational performance, innovation development, transparency enhancement, trust building with stakeholders, and resource resiliency in the long run (Almnadheh et al. 2025; Hammad et al. 2025; Panteleev et al. 2024). In the water space, ESG integration is linked to superior pollution management, greater resource-use efficiency and stronger action against climate-related risks. As circular economy concepts, next-generation digital monitoring and cross-sectoral governance approaches are increasingly integrated into the way water utilities operate, ESG frameworks provide guidance to ensure these efforts support overarching sustainability and regulatory objectives.

From this perspective, water utilities should not treat ESG as a reporting requirement but as a strategic enabler to influence investment choices, operational planning, risk management, and stakeholder engagement.

1.2. Context of Águas do Tejo Atlântico and Emerging Regulatory Pressures

Being the concession holder for the regions of Grande Lisboa and Oeste, Águas do Tejo Atlântico, S.A. (AdTA) is one of the largest water and waste management utilities in Portugal. The organisation is a key member within the Águas de Portugal (AdP) Group, who own

Group part

majority stakes in multiple other water and waste management utilities across Portugal, with some international projects also underway. AdTA serves more than 2.3 million inhabitants and 23 municipalities which includes the municipalities of Lisbon, Cascais, Sintra, Loures, Torres Vedras and Caldas da Rainha and it does this through an extensive network of wastewater infrastructure.

The company operates under strong oversight from shareholders, municipalities and regulatory bodies. Their economic and financial management are subject to strict external auditing alongside rigorous investment controls. AdTA must navigate a somewhat of a minefield of regulations and requirements, driven by the need to comply with AdP group strategies, Portugal's Decree-Law 119/2019 and national water management strategy (Água que Une), the EU's Water Framework Directive (WFD) and taxonomy requirements, and the company's commitment to the United Nations Global Compact (UNGC). This is alongside meeting the expectations of the municipalities and communities which they serve. Furthermore, AdTA operates under the supervision of ERSAR (Entidade Reguladora dos Serviços de Água e Resíduos) who are a Portuguese regulatory authority for water and waste services, and they are also subject to environmental monitoring by APA (Agência Portuguesa do Ambiente) who are the agency responsible in ensuring environmental policies are implemented and adhered to in Portugal (Ramos 2021).

Like many European and Global utilities operating in this field, the increasing pressures from climate change, water scarcity, rising energy costs, and tighter regulations alongside changing public expectations, demand for greater transparency and stakeholder engagement. This highlights the need for the enhanced integration of Environmental, Social and Governance (ESG) in the company's long-term strategy.

1.3. The Fundamental Challenge: Embedding ESG into Corporate Culture and Improving Reporting

Despite the advantages of ESG frameworks, studies demonstrate that organizations, particularly those operating in the public utilities sector, encounter ongoing difficulties translating ESG values into day-to-day practice and policy. Common impediments found across reviewed studies include absence of standardized measures, poor quality data, institutional fragmentation, resource limitations (both financial and human), regulatory density, or cultural resistance to transparency or long-term planning (Hammad 2025; Sepetis et al. 2024).

These obstacles are of special relevance for AdTA. As a technically focused company with strong engineering skills, the move to integrated ESG management demands:

- building ESG literacy in its leadership and operational teams;
- improving inter-departmental coordination to minimize fragmentation;
- implementing harmonised data systems which link the environmental, financial and operational aspects;
- strengthening governance arrangements to improve responsibility, accountability and clarity;
- culture shift toward openness, engagement with stakeholders and long-term sustainability focus.

While regulatory interventions and technological solutions will play a role, this transformation is more of a cultural and organizational change. It calls for a transparent strategic framework describing priorities, responsibilities, enabling technologies and the organization model for proper ESG integration.

1.4. Project Scope, Methodology and Constraints

This project's completion has been done via analysing AdTA's sustainability disclosures and internal documentation, relevant regulatory texts, academic literature, and established ESG frameworks. Key frameworks used in our research include CSRD/ESRS requirements, EU Taxonomy principles, and UN Global Compact/SDG alignment, ensuring that the analysis is grounded in widely recognised and verifiable standards. Furthermore, direct engagement with AdTA, through weekly meetings and semi-structured interviews with key managers in the organisation, has complemented our work by providing insights into data flows, governance challenges, and organisational barriers. Members of the team also attended an Innovation Pathway event hosted by the company where they got a tour of the facility and a chance to grasp a deeper understanding of the organisational context. This event also allowed the team to connect with a recent master's graduate, who was later interviewed to gain valuable insights from her thesis work with AdTA.

This work adopts a managerial and strategic perspective of the project with minimal inclusion of technical engineering analyses of treatment processes, plant-level operations, or infrastructure design. This approach reflects the backgrounds of educational and professional expertise held by the students. It is important to note that the depth of data collected is somewhat constrained due to the project's short time frame (September–December). Additionally, the analysis relies heavily on publicly available sustainability reports and selected internal documents with limited access to plant-level, real-time, or externally assured ESG data. Constraints over team management and organisation have also been apparent, with two of the three team members working jobs simultaneously.

2. AdTA & Project Context

2.1. Overview of AdTA's Mission and Operations

Operationally, AdTA manages 100 wastewater treatment plants (WWTPs) also referred to internally as “Fábricas de Água” (“Water Factories”), 292 pumping stations, 5 submarine outfalls and employs roughly 400 members of staff (AdTA 2024). In 2024, AdTA treated around 218 million m³ of wastewater in its own facilities whilst returning a total of roughly 220 million m³ of treated water, which includes effluents they received from external entities, back into the environment.

AdTA has already developed a relatively mature ESG profile, showing visible commitments to improving their sustainability. The name Fábricas de Água, highlights a resource recovery model that emphasises transforming wastewater into valuable products and capturing the value of these resources. This concept involves three pillars;

1. reuse of treated wastewater for purposes such as irrigation,
2. recovery of valuable resources in the form of biogas for instance,
3. returning high-quality treated water back into river and coastal ecosystems.

Despite their current ESG profile showing strong incentives, initiatives were often identified to have common issues primarily over their strategic management. This project commenced with a strong motivation from AdTA to fully integrate ESG into their corporate strategy to improve their operational efficiency and overcome cultural resistances. Through providing actionable insights, this work hopes to enable them to improve the effectiveness of their circular and sustainable initiatives alongside being able to more easily navigate their complex regulatory landscape.

2.2. Summary of Current ESG Position

Environmental

Through meeting with the company representatives alongside conducting our own research, it became clear that there was still work to be done to evolve their performance in 4 major areas:

Wastewater re-use

Only 1.4% of AdTA's total volume of treated wastewater was reused in 2024. Small-scale municipal and private pilot projects make up majority of companies current reuse activities, with AdTA currently having no clear long-term strategy or roadmap for expansion. Feasibility analysis and research is underway but will take time so presently decisions are largely intuition based. Cultural resistance from some target clients and infrastructure constraints, alongside misaligned incentives with municipalities has also hindered efforts to expand reuse.

Energy Efficiency

In 2024, AdTA was approximately 25% energy self-sufficient, producing 22.3 GWh of energy internally. However, the company currently has no defined net-zero roadmap or long-term targets for decarbonisation. Energy KPIs at plant level are limited, and actions to improve efficiency are not being systematically benchmarked or documented hindering decision making. Therefore, opportunities to optimise operations, heat recovery, and biogas production aren't reaching their full potential.

Biodiversity Stewardship

Biodiversity related actions remain largely descriptive in the company's reports and aren't being supported by performance-based KPIs. Reports on operational incidents such as the 91 inundations and 16 collapses that AdTA reported in 2024, provide little contextual information about environmental impacts or corrective measures. Furthermore, AdTA's current lack of real-time water-quality transparency, ecosystem indicators, and systematic outfall monitoring

Group part

is limiting their ability to assess, manage and communicate its ecological performance effectively.

Valorisation and Use of Sludge

Whilst reporting a 99% sludge valorisation rate in their 2024 report, there is limited transparency regarding its end uses. Moreover, no information is included about nutrient recovery rates and little regarding details on energy generation from sludge. According to the company representatives, AdTA does not currently hold licenses enabling them to commercialise residuals directly and instead they are required to pay intermediaries for sludge removal which results in a loss-making model. Furthermore, the potential to integrate sludge valorisation and usage into broader circular economy and energy recovery objectives is being constrained by poor traceability resulting from KPI and strategic planning weaknesses.

Social

Águas do Tejo Atlântico's (AdTA) Social pillar has a people-approach that joins internally, workforce development investments with the proactive involvement in communities served. Investing in skills and life-long learning continues to be a structuring element of managing people. AdTA maintained its practice of organising structured training courses and personal development plans featuring both transversal and strategic skills (AdTA 2024). Currently the company was involved in the Águas de Portugal Group internal program on social responsibility granting, for the 2024/2025 school year, scholarship to employees' children supporting higher and special education actions and promoting equal opportunity in learning (AdTA 2024).

Health and safety in the workplace are addressed with a strong culture of prevention, involving awareness-raising campaigns, technical training, participating in activities such as the World Day for Safety and Health at Work or the European Week for Safety and Health at Work.

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Diversity, equal opportunities and non-discrimination are also enshrined in AdTA's governance and HR policies, underpinned by its no-discrimination policy, Code of Ethics and Conduct and the collective labour agreement, based on ILO conventions (AdTA 2024). The company actively celebrates the European Diversity Month and collaborates with organizations like APPDI and GRACE.

On top of the internal, AdTA also focuses on environmental education and sustainable sensitization in serving communities. School visits, educational workshops and outreach activities were also implemented by the company, with a highlight on invoking changes in behaviour using programs like Participate in Ciência Viva and other national programs.

Governance

Reporting fragmentation, unclear governance, cultural barriers

As a relatively young, publicly owned wastewater utility within the AdP group, AdTA has developed its core information systems primarily to satisfy regulatory and financial reporting obligations (e.g. ERSAR, APA, environmental permits, EU-funded projects), with data generated in specialised technical systems (SCADA, LIMS, maintenance, HR, finance) and channelled into separate reporting streams (Águas do Tejo Atlântico 2023). On top of this legacy, different public reports have emerged over time that AdTA's own sustainability disclosures, the AdP group sustainability report and the statutory annual report and governance report, each based on slightly different scopes, consolidation logics and indicator sets (AdP, Águas de Portugal 2025). This pattern is consistent with the broader ESG literature, which shows that when sustainability information is produced in fragmented systems and for multiple, uncoordinated reporting purposes, organisations tend to rely on manual consolidation, face inconsistencies across indicators and struggle to establish a single "source of truth" for ESG data (Fragidis et al. 2025).

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Unclear ESG governance at AdTA similarly reflects its institutional configuration as a state-owned enterprise embedded in a wider group structure. Strategic orientations, risk appetite and sustainability expectations are partly defined at AdP group level and partly at the level of AdTA's own Board of Directors, with governance documents traditionally focused on compliance, internal control and risk management (Águas do Tejo Atlântico 2023). There is no evidence of a dedicated board-level sustainability or ESG committee with a clear mandate, decision rights and explicit linkage to remuneration and performance indicators; responsibilities for environmental and social topics appear dispersed across several corporate functions and group entities. Studies on water governance and public utilities highlight that such institutional fragmentation is common and typically weakens strategic oversight of sustainability, because no single body is clearly accountable for ESG outcomes and for the integrity of non-financial reporting (Ahopelto et al. 2024).

Cultural barriers are reinforced by the traditional operational and regulatory focus of European water utilities. AdTA's mission is framed around wastewater treatment, environmental protection and compliance with regulatory standards (Águas do Tejo Atlântico 2023a; 2023b). In this context, sustainability is often interpreted as "business as usual" delivered through permits and technical performance, while detailed ESG reporting is perceived as an additional administrative burden rather than as a core management and strategic tool. Empirical work on water utilities and water governance underscores that limited awareness of broader sustainability expectations, institutional path dependence and weak cross-functional collaboration constitute major obstacles to more integrated, outcome-oriented practices (Rieiro et al. 2025). At the same time, the CSRD and ESRS introduce stringent, forward-looking and in many cases assured sustainability reporting requirements and are explicitly designed to trigger behavioural and organisational change (EFRAG 2022) (Fragidis et al. 2025). For a company such as AdTA, this creates a structural gap between an established culture centered

on technical compliance and the emerging expectation to use ESG information as a strategic lever in board decision-making, risk management and stakeholder engagement.

2.3. Why ESG Integration Matters for AdTA

Regulatory Drivers: CSRD, ESRS, EU Taxonomy and Global Standards

AdTA works within an industry that is increasingly regulated in terms of sustainability. In line with the EU Green/Blue Deal, CSRD, ESRS and the EU Taxonomy, the company should also deliver transparent, comparable and externally assured ESG disclosures in accordance with European corporate standards for essential service providers. There is evidence in academic writings that such alignment represents a pivotal factor supporting an effective ESG implementation, particularly as clear governance systems, strong reporting mechanisms and harmonisation with regulatory frameworks (Almnadheh et al. 2025) (Panteleev et al. 2024). Despite this, conclusive evidence from the paper indicates that several major operators in Europe have already embedded CSRD-ready reporting systems including:

- Veolia which articulates double materiality as the “cornerstone of CSRD” and systematically frames impacts, risks and opportunities.
- Holcim embeds a complete ESRS-compatible double materiality assessment into their Integrated Annual Report.

These cases reflect a general regulatory convergence on auditable ESG reporting and in doing so they reiterate the fact that AdTA will have to rapidly upgrade their ESG systems in order not to be caught short of compliance and fully prepared for CSRD publication.

Financial Drivers: Effective, Regained Resource and Risk Mitigation

The operational model of AdTA is already providing tangible returns: 3 million m³ of recycled water, 22.3 GWh of renewable energy production, cost savings in the range 40-50% compared

Group part

to the grid water and waste recycling over 99%. Enhancing ESG integration and with better data, governance and decision processes will reinforce these outcomes.

The literature is also replete with evidence that ESG adoption and be positively associated with operational performance, firm innovation, and long-term financial stability (Hammad et al. 2025).

In the document it is highlighted that ESG integration:

- Improves natural asset resilience to climate risk;
- Lowers operating costs through optimizing the consumption of energy and resources;
- Is EU Taxonomy-aligned, enhancing access to green finance;
- Prevents exposure to penalties, regulatory non-compliance and environmental events.

The benchmarking cases underpin this economic logic:

- Holcim generates 36% of its revenue from sustainable products as a demonstration that circular and low carbon business models can be more profitable than traditional ones.
- Veolia bakes ESG into management incentives and operational KPIs, showing how environmental performance supports financial results.

For AdTA, a €98.6m operator with substantial long-lived infrastructure, ESG is both a risk-mitigating tool and a value-creating opportunity.

Reputational Drivers: Stakeholder Trust and Sector Leadership

Given the public nature of AdTA as an environmental services provider, controlled by ERSAR and APA, reputation also impacts on its ability to work with municipalities and its social licence to run. The organization engages with governments, regulators, communities, NGOs, suppliers, academia and financial institutions; as such transparency and accountability are critical to its legitimacy.

Research in the applicable literature found in the appendix suggests that ESG adoption increases stakeholder confidence and credibility, increasing public-sector legitimacy specifically in water utilities (De Nicolò 2020; Sepetis et al. 2024).

Already collecting substantial awards like IWA Project Innovation Award, WEX Global Award, among others, yet the growing demands in terms of climate resilience, circularity, community impact and transparency require AdTA for a deeper ESG integration so it will be able to maintain and boost its unique leadership within Portuguese water sector.

3. Governance as the Foundation

Governance represents a comprehensive system of rules, processes, and incentives that underpins the operational framework of an organization. In the water and wastewater sector, this “operating system” decides how priorities are set, how resources are allocated, and how managers are held accountable. If this system is weak or inconsistent, ESG strategies remain rhetorical: sustainability becomes a collection of fragmented projects and communication efforts rather than a set of embedded practices guiding everyday decisions. (Nicolo et al. 2023).

The Impact of Regulatory Frameworks

Evidence from the Portuguese water sector shows that robust, coherent governance frameworks can radically change sector performance. Before the reforms of the 1990s, Portuguese water and wastewater services suffered from low coverage, poor water quality and high losses. Following the restructuring of the sector coverage, service quality and operational indicators improved substantially. Water supply coverage increased from about 80% to around 96%, quality test compliance rose from roughly 50% to almost 99%, and non-revenue water fell from close to 50% to under 30%. These gains did not come from ownership changes alone, but from a tighter institutional and regulatory framework. (Marques & Simões 2020).

Strategic Alignment

In this regulatory context, strategic alignment inside utilities is not optional. Without a governance framework that links capital expenditures (CAPEX), maintenance policies, innovation projects and explicit ESG objectives, each department optimises its own agenda, and the overall impact of sustainability efforts is diluted. Governance is what forces CAPEX planning, asset management and innovation pipelines to reflect resilience, decarbonisation, circular economy and social priorities, rather than short-term engineering or budget constraints. Benchmarking and performance analyses of water utilities show that those utilities who formalise asset management practices and manage investments within a clear strategic framework tend to be more efficient and resilient, especially in water-stressed regions. Coherent governance therefore acts as the “translation device” between ESG strategy on paper and day-to-day technical and financial decisions (Marques & Simões 2020).

Risk Management in the Water Sector

Risk management is structurally central in the wastewater sector. Utilities face interlinked climate, hydrological, operational, health, fraud, and regulatory risks. Floods, droughts, asset failures, treatment incidents and non-compliance can rapidly escalate into service interruptions, environmental damage and reputational shocks. Comparative work on water governance in Portugal highlights how institutional and regulatory reforms have improved the system’s capacity to identify and mitigate these risks through clearer oversight and more systematic monitoring. (Marques & Simões 2020). When ESG factors are explicitly integrated into risk registers, reporting routines and decision criteria, utilities can move from a reactive stance to a preventive approach.

The Value of Stakeholder Engagement

Stakeholder engagement is another non-negotiable component of ESG governance in water utilities. Water is widely perceived as a guaranteed service: people expect safe, affordable water at the tap and reliable wastewater treatment, and tend to ignore the underlying infrastructure, risks and costs. Yet the literature on public utilities shows that structured stakeholder engagement is one of the main levers for creating public value, enhancing legitimacy and aligning services with social expectations. A content analysis of ESG reports from Italian public utilities (Bonetti et al. 2023) finds that, despite their mandate to serve a broad set of stakeholders, engagement processes are often narrow, one-way and weakly dialogic, with limited two-way communication and few mechanisms to integrate stakeholder input into strategy. For a water operator, governance “done properly” therefore means having clear rules on who is engaged, on which topics, through which channels and how insights from communities, municipalities, regulators, employees and investors are fed back into investment planning, service design, tariff debates and not simply listing meetings in sustainability reports.

Role of governance in enabling Environmental & Social performance

Governance is increasingly framed not as a separate “G” pillar but as the architecture that decides which environmental and social impacts are prioritized and how performance information is produced, validated and used. (Padilla-Rivera et al. 2025) show that integrating life-cycle sustainability assessment with ESG factors only improves environmental and social outcomes when governance structures ensure that impact metrics are embedded in decision rules rather than confined to external reporting. In water utilities specifically, case studies of municipally owned operators in Italy and France indicate that board composition, the presence of sustainability/CSR committees and transparency obligations shape both the scope and depth of ESG disclosure, and thus which environmental and social themes are rendered visible to managers and stakeholders (Ligorio et al. 2022; Martínez-Martínez et al. 2024). This is

Group part

consistent with broader evidence that hybrid governance models and stakeholder pressure influence utilities' sustainability performance scores and disclosure breadth, reinforcing the idea that governance mediates how environmental efficiency, climate resilience and equity are operationalized. At a cross-sector level, ESG maturity models and data-governance frameworks underline that moving from basic, compliance-driven reporting to integrated or transformational ESG performance requires strengthening oversight structures, clarifying responsibilities for ESG data and embedding ESG criteria into capital allocation, risk management and incentive schemes (Cruz and Matos 2023; Orrick 2023). Empirical analyses of ESG disclosure also link stronger governance and higher-quality non-financial reporting to lower financing costs, better access to green capital and reduced risk, which in turn expand utilities' capacity to invest in environmental improvements and social program.

KPI accountability

In contemporary ESG practice, KPIs are the hinge between high-level commitments and real accountability: culture, risk management and reporting frameworks become credible only when translated into a limited set of indicators that managers monitor, discuss and use to make trade-offs. In network utilities this is particularly evident: governance environmental and social KPIs provide both an internal control device and an external signal to regulators, investors and citizens about how seriously an organisation treats its responsibilities (Caputo & Fasiello 2024). At the same time, moving from a "box-ticking" or purely compliance-driven approach to a more integrated or leading ESG model depends on establishing coherent, decision-oriented KPI systems supported by solid data architectures and clear ownership of each metric across the organisation (Cruz & Matos, 2023). Global ESG and compliance reviews highlight that indicators such as the share of operations covered by internal control frameworks, the proportion of material risks identified and actively monitored, and the number and resolution rate of compliance incidents are essential to consolidate fragmented initiatives into a single,

organisation-wide risk and reporting model (Boston Consulting Group 2022). In the water-utility literature specifically, empirical studies show that governance structures and transparency tools are strongly associated with the breadth and quality of ESG disclosure, confirming that KPIs are not neutral technical artefacts but reflect and reinforce underlying governance choices (Ligorio, Caputo and Venturelli 2022; Martínez-Martínez et al. 2024). On the social side, researchers repeatedly emphasise workforce-related indicators such as headcount, gender and age distribution, percentage of permanent contracts, training hours, accident frequency and severity, absenteeism and turnover, which capture the organisation's responsibility towards its employees and tend to be reported more systematically than more complex "impact" measures on communities; yet both internal and external social KPIs are necessary if ESG reporting is to support genuine accountability rather than a narrow labour-compliance narrative.

4. Strategic Recommendations

4.1. Governance Priorities

Priority 1: Establish a dedicated ESG / Sustainability Committee

The first governance priority is therefore to establish an ESG or Sustainability Committee at Board level (or as a joint committee with Risk/Audit), with a clear mandate to:

- Oversee ESG strategy, including climate, circularity, water quality, health and safety, and social topics relevant for a wastewater utility.
- Monitor non-financial performance against a defined set of KPIs, including targets aligned with national and EU regulatory expectations.
- Supervise CSRD/ESRS readiness and the quality of ESG reporting and disclosures.
- Ensure structured stakeholder engagement (regulators, municipalities, communities, employees) is considered in strategic decisions and capital allocation.

Group part

The committee should include at least one member with demonstrable ESG/utility experience and work closely with the existing Audit and Risk Committee to avoid overlaps and gaps.

Priority 2: Design and embed an integrated ESG performance dashboard

A second governance priority is to design an integrated ESG dashboard that aggregates the main environmental, social and governance indicators into a single, board-ready reporting tool.

Involves:

- Consolidating critical KPIs from operations (energy use, emissions, water quality, sludge management), HR (health and safety, training, diversity), procurement and finance, with a clear link to strategic objectives.
- Defining KPI ownership by department, with explicit roles and responsibilities for data collection, validation and commentary.
- Establishing a data governance model (data owners, data stewards, standard definitions, control checks) to reduce manual work and increase reliability.
- Integrating the ESG dashboard into the regular performance management cycle (e.g. quarterly board packs) rather than treating it as an ad-hoc sustainability report.

Without this integrated dashboard, board oversight remains reactive and management decisions are based on partial or delayed information

Priority 3: Strengthen internal controls and external assurance over ESG information

The third priority is to progressively align ESG information with the level of control and assurance applied to financial data.

Involves:

- Extending the internal control framework to key ESG processes (GHG accounting, energy and water consumption, effluent quality monitoring, incident reporting, stakeholder complaints) with documented procedures and control activities.

Group part

- Integrating ESG risks into the enterprise risk management (ERM) framework and risk register, with clear links to mitigation actions and owners.
- Defining a roadmap for external assurance, starting with limited assurance on the most material indicators and gradually expanding both scope and level of assurance in line with CSRD requirements.
- Clarifying the role of Internal Audit in reviewing ESG controls and data quality as part of its multi-year audit plan.

Priority 4: Upgrade board oversight, accountability and incentives for ESG performance

The fourth priority focuses on strengthening oversight mechanisms and aligning incentives, which involves:

- Updating Board charters and key policies (Code of Ethics, risk policy, remuneration policy) to explicitly integrate ESG responsibilities and expectations.
- Developing a clear RACI matrix for ESG governance, clarifying the roles of the Board, ESG Committee, Executive Committee, functional directors and operational teams.
- Linking a portion of variable remuneration for executives and senior managers to a small set of robust ESG KPIs (e.g. safety performance, energy efficiency, regulatory compliance on effluent quality, employee engagement), with transparent targets and measurement rules.
- Implementing regular ESG training for Board members and senior management to ensure they can challenge management effectively on ESG risks, opportunities and trade-offs.

4.2. Environmental Priorities

Priority 1: Embed Environmental and Social Metrics into Strategic and Financial Decision-Making through a Unified KPI Framework

Environmental and social considerations should become fully integrated into corporate planning, investment prioritisation, and risk management. Embed clear and standardized environmental indicators into executive decision processes to ensure that capital allocation, performance evaluation, and strategic direction are informed by sustainability outcomes.

Ensure that the new KPIs are performance-based to more clearly measure outcomes and effectiveness, rather than just measuring activities. Furthermore, introduce KPIs that incorporate multiple dimensions, such as the amount of energy used to treat water to a certain standard. This will strengthen the quality of information being generated, improve decision making and evaluate environmental performance consistently across sites.

Priority 2: Utilise Digital Tools to aid Environmental Monitoring and Reporting

An effective platform to monitor, reduce errors, automate data collection, and ensure consistent traceable information should be used for performance assessments, decision making, and reporting. Therefore, integrating digital tools such as SCADA systems, automated data-pipeline platforms, and centralised environmental data management systems is recommended to consolidate and verify the information coming from all WWTPs.

Priority 3: Strengthen Internal Controls and Evidence Tracking

Internal controls through the likes of standardising documentation and creating systems to formalise procedures should be implemented to ensure the integrity of the company's environmental data. Examples of what this might look like include standardised data-collection procedures, validation checklists, audit trails, a central evidence repository, role-based access permissions, version-controlled templates, and regular data-quality reviews. This

will help to ensure that what is being reported is accurate, traceable, and reliable for internal performance evaluation.

Priority 4: Strengthen Environmental Performance Through Strategic Partnerships and Stakeholder Engagement

AdTA should deepen its collaboration with external stakeholders such as municipalities, conservation NGOs, research institutions, community groups, and industrial partners. This will help to enhance environmental performance and outcomes across all operational areas. Strategic partnerships can provide AdTA with specialised expertise in areas like biodiversity management, circular economy innovation, and ecosystem restoration, while structured stakeholder engagement can ensure that environmental initiatives are aligned with local needs, scientific best practices, and community expectations.

Priority 5: Training and Cross-Functional Collaboration

Conduct regular training and cross-functional collaboration to improve environmental performance throughout the company. This should involve training in strategic and regulatory requirements, understanding KPIs, consistent and accurate measurement methods, understanding of digital tools and data platforms, and standard protocols. This will promote alignment and efficient progress towards ESG goals and targets by improving competencies, knowledge, and enhanced clarity.

4.3. Social Priorities

Priority 1: Supporting the Wellbeing & Safety of Our People

AdTA shall combine the current wellbeing benefits in a single “Tejo Bem-Estar” program, maintaining existing health insurance, psychological support and internal well-being activities but adding ergonomic coaching, and exercise. A work–life conciliation proposal derives from this, with inspiration in EPAL/AdVT, to establish a Conciliation system comprising a Team,

Group part

a Digital Box for needs and requests and support partnerships. Psychosocial risk prevention will be complemented with biannual evaluations and an annual “Tejo Pulse Survey”, based on the Danone People Survey, as well. In what concerns Safety, AdTA should renovate tools with the transposition of the digital model used by AdVT “OnPocket – Tejo Atlântico”, allowing easy access to Risks, EPI’s and procedures. Cross-cutting initiatives are a guided Wellbeing & Safety Champions network and people focused campaigns, including Mental Health Week, Safety Week, Movement Day and Family Day.

Priority 2: Improving Employee Engagement & ESG Education

The “NextGen Tejo” program which is already implemented should include informal cross-generational lunches (“Gerações à Mesa”), full participation in the AdP Group Mentoring Program, and greater team networking. Volunteering should be carried out under the umbrella of “Gota a Gota Tejo”, also following the Group’s model, with simple activities but involving mass participation as beach clean-ups, school water sessions all under “O Mar Começa Aqui – Tejo” actions in conjunction with ABAAE.

Priority 3: DEI (Diversity, Equity and Inclusion)

A DEI Council should manage all DEI initiatives, Girl MOVE’s participation, Engenheiras por um Dia, actions of the Paralympic Committee and iGen; SEMEAR partnership (workshops, visits and Christmas initiatives) and adaptation of EPIS Social Scholarships to AdTA’s territory.

This Council must have dates organized around DEI, as well as inclusive communication.

An enhanced version of the Ethics Line will be maintained as the formal reporting mechanism for discrimination, harassment, or non-inclusion.

Priority 4: Increase Community & Stakeholder Engagement

All community activities should be incorporated into a Program with coherent branding. This covers environmental teaching, visits, Water Ambassadors, Eco-Schools and citizen science

Group part

programs. AdTA must establish new territorial and educational landmarks following the model EPAL–AdVT:

- Centro de Educação Ambiental de Beirolas (CEA) as being a permanent education and community hub; year-on-year “Tejo Community Labs” engaging community action (e.g. Bosque Tejo), short talks and stakeholder commitment.

In addition to the surveys, a feedback mechanism will then represent an organized but pragmatic model to listen to stakeholders.

4.4. Cross-Pillar Roadmap for ESG Integration at AdTA

Below is a roadmap to operationalise the priorities identified previously across all three pillars to provide AdTA with a fully integrated plan for ESG improvement. The aim of this roadmap is to provide a realistic strategic timeline, across three different time frames, outlining at what stage to implement the various recommendations that have been put forth. Short, medium, and long term, suggestions have all been presented, and they reflect AdTA’s capacity, the required changes, and regulatory timelines. The roadmap is structured by three guiding principles:

1. Establish the foundations first: These initial actions will focus on building the structures for effective ESG governance and performance.
2. Ensure organisational capability: Here the systems, digital tools, and controls needed will be strengthened to improve operational ESG capabilities
3. Shift to having ESG fully integrated into organisation: Finally at this stage the aim will be to have ESG fully embedded into AdTA’s organisational culture as well as their strategies, planning, investments, and reporting.

4.4i. Short-term actions (0–6 Months)

In the short term, the goal is to establish a structural foundation that clarifies responsibilities within the company and initiates environmental and social initiatives of high priority to AdTA.

Governance

Set up ESG governance structure and committee

- Establish an ESG/Sustainability Committee of the Board (or a joint ESG–Risk committee) anchored in the existing Manual de Governo, clarifying that it is a formal commission of the Board rather than a parallel structure.

Clarify responsibilities and ownership for CSRD/ESG by assigning:

- the Board/ESG Committee as overall owner of the sustainability statement;
- the Executive Commission as responsible for implementation;
- each Directorate as owner of its relevant ESG KPIs;
- operational “data owners” at coordinator/area-manager level

Connect ESG to integrity, risk and PPRCIC from the start

- Identify the internal PPRCIC/integrity and anti-corruption focal point (as per the most recent PPRCIC report) and ensure this role sits permanently in the ESG Committee.

Require that this focal point brings into the ESG Committee: the corruption risk map by process, the status of RGPC measures, and the main inputs needed for future ESRS G1 (business conduct) disclosures.

Create an initial ESG data and control framework

- Develop an “ESG Data File v1” and a basic reporting calendar, mirroring the responsibility and control model already used for financial and group reporting, use simple attestations (each data owner must sign off on the completeness and accuracy

Group part

of the data they submit). Link the mapping of environmental data sources and the first social surveys/assessments (Tejo Pulse, psychosocial assessment) to this ownership structure, so it is clear who is responsible for data quality and follow-up.

Environmental

- Map all the existing environmental data sources and measurement systems already in place across WWTPs and finish defining performance-based KPIs for all environmental areas. Consider KPIs on training, regulations, and effective use of digital systems.
- Continue researching and zone mapping to target high potential reuse areas whilst also undertaking initial materiality assessments of treated wastewater to identify properties, reuse applications, stakeholder needs, and risks.
- Approach municipalities and other relevant authorities with the aim to explore shared benefits models for water reuse and ecological stewardship.

Social

These initiatives organize the key components of Tejo Atlântico's Social ESG model – structure, visibility and quick wins for employees and stakeholders.

- Tejo Wellbeing Program

An integrated way of looking at wellbeing, inspired by the best practices in AdP Group. It includes preserving benefits and integrating new services (ergocoaching, workplace micro-gymnastics)

- Formation of the Conciliation Team & Digital Conciliation Box

Established as a mechanism for employees requesting schedule adjustments, family support, local partnerships, and internal facility enhancements.

- First Psychosocial Assessment + Preliminary Tejo Pulse Survey findings

A brief, confidential biennial psychosocial assessment for fatigue stress and emotional needs.

Group part

The inaugural Tejo Pulse Survey (derived from the Danone People Survey) measuring engagement, culture, wellbeing and satisfaction providing feedback to set our likely baselines for improvement.

- The Internal DEI Council is born

A multidisciplinary team of volunteers working on all DEI programs (Girl MOVE, Engenheiras por um Dia, Paralympic Committee, SEMEAR).

- Launch of the NextGen Tejo Programme

Concrete early-stage actions: “Generations at the Table” sessions each month to foster intergenerational learning.

- “Gota a Gota Tejo” First Core Volunteering Efforts

The first simple volunteering activities that make an impact: Beach clean-up with ABAAE and “O Mar Começa Aqui – Tejo” awareness activities in schools.

4.4ii. Mid-term actions (6-18 months)

At this point, the aim is to strengthen AdTA’s systems, digital tools, internal controls and organisational capabilities across all parts of ESG.

Governance

- Formalise ESG Committee and governance roles, update the internal regulations of the Board and Executive Commission to explicitly include: ESG and CSRD oversight, ESG risk governance, and integration with integrity/PPRCIC. Environmental and Social initiatives (biodiversity, sludge valorisation, DEI programs review)
- Update delegation of powers and integrate ESG into performance, for approval of strategies, thresholds for CAPEX/OPEX projects.
- Extend PPRCIC logic to broader ESG risk management aligning risk categories with future ESRS 2 and environmental and social ESRS. Use the existing PPRCIC

Group part

methodology as the basis for a broader ESG risk register including environmental, social, integrity and reputational risk.

- Strengthen ESG data systems, internal controls and dashboard governance. Make the dashboard a mandatory element in management review for Environmental and social modules. Structured ESG reporting system maintaining clear ownership, validation workflows and audit trails. Integrate the dashboard into regular management and board reporting packages.

Environmental

- Integrate all relevant environmental indicators into the ESG dashboard to increase accountability across departments and carry out regular training on circularity, environmental KPIs, digital tools, and regulatory developments.

Water Reuse

- Standardise measurement systems for water quality, nutrient contents, reuse volumes and risk indicators across all WWTPs. Undertake continuous systematic materiality assessments to evaluate treatment performance, potential re-use pathways, and any ecological risks.
- Develop frameworks with municipalities that involve shared financial benefit models and structure for collaborative governance.

Energy Efficiency & Transition

- Deploy digital optimisation tools including SCADA upgrades, AI analytics, and digital twins.
- Target large WWTPs for upgrades in energy-intensive operational areas such as aeration or pumping to optimise plant flows and reduce avoidable costs.

Group part

Biodiversity & Ecosystem Stewardship

- Install systems to monitor effluent quality, nutrient loads and overflows in real time, comparing them against parameters to assess ecologically impacted areas. Create publicly available dashboards that display this data, increasing transparency and accountability.
- Enhance treatment and discharge systems through nature-based solutions such as wetlands or riparian buffers near discharge zones. Treat maintenance as a method of ecological protection.

Sludge Valorisation & Circular Economy

- Optimise systems for anaerobic digestion at large WWTPs.
- Introduce enhanced monitoring, documentation and tracking for biosolids to guarantee that reuse is safe, certified and traceable. Implement differentiated KPIs for energy, nutrient and material recovery, as well as use pathways.
- Explore regional bioresource hub models, integrating municipal sludge with other organic wastes to maximise biogas production and circular-economy benefits.

Social

- On Pocket App (Health + Safety Inclusion)

A Platform for Co-creating Work Management The digital toolkit that empowers frontline workers to: Installation-specific risks, Required PPE, Key procedures.

- Internal People-Driven Campaigns and Champions Network

Strengthening culture through: Wellbeing & Safety Champions who motivate their Teams and drive their campaigns for key initiatives – Mental Health Week, “We Are Safe” safety week etc.

- Participation in Key DEI Programs

Group part

Visibility, Inclusion and Talent mobility expanding through: Girl MOVE Academy, Engenheiras por um Dia, Paralympic Movement, SEMEAR

- Complete Implementation of the Tejo Volunteering Program

The annual Gota a Gota Tejo actions reach the status of tradition, counting on intense participation from employees, their families and management.

4.4iii. Long-term actions (18-36 months)

At this stage, the goal is to ensure that ESG is fully integrated into AdTA's strategy, culture, planning, and reporting.

Governance

- Consolidate the ESG Committee as a core Board committee.
- Major strategic decision reviewed by the committee for ESG implication before Board approval.
- Fully embed ESG into remuneration and investment decision-making. Link a defined share of variable remuneration for top management and critical roles to ESG KPIs approved by the Board.
- Align integrity, PPRCIC and CSRD/ESRS G1 requirements. Map each ESRS G1 requirement to the PPRCIC model making sure the indicators produces by the system are directly reusable in the sustainability report.
- Achieve full CSRD alignment and integration with financial reporting.

Environmental

Wastewater Reuse

- Scale reuse across multiple schemes using research and learnings of pilot tests. Water quality and pricing standards will need to be harmonised, and reliable volumes will need to be consistently available.

Group part

- Test and develop infrastructure plans for introducing decentralised reuse systems.

Energy Efficiency & Transition

- Install upgrades to WWTPs at a large scale to improve energy efficiency through, improved aeration systems, more efficient pumps, and automated controls.
- Have clear and actionable long-term goals for emissions reduction and energy neutrality, using national and international climate targets and trends as a guide.

Biodiversity & Ecosystem Stewardship

- Establish formal partnerships with municipalities, basin authorities and NGOs, to work together in protecting local ecosystems and set up long-term ecological restoration projects.
- Test new treatment technologies and train staff to manage advanced processes to prepare for stricter regulations regarding nutrient and micropollutant removal.

Sludge Valorisation & Circular Economy

- Develop regional so-called bioresource hubs that can treat sludge and organic waste together should the mid-term exploratory efforts show value in doing so.
- Use up-to-date technologies for nutrient recovery alongside continuously improve internal treatment and production processes for biogas.
- Strengthen partnership with clients such as farmers or industrial clients to ensure desirability and value capture, alongside maintaining safety and measuring it's soil restoration effectiveness.

Social

- Full Capacity Tejo Living Lab (CEA)

Full activation of Beirolas as a Tejo Living Lab: the cornerstone for knowledge, partnerships, workshops and dialogue on stakeholders as well as family/community events. Here, all the

Group part

school projects, cooperation with NGOs, municipal operations and joint work with universities come together.

- Tejo Community Lab Day

A high final event on which various actors are joining (schools, NGO's, municipalities, universities, families and employees from the sector).

- Regular use of Surveys and Stakeholder Feedback

Progress is continuously monitored using: Psychosocial assessments, Tejo Pulse Survey, volunteer participation data, DEI metrics, stakeholder insights.

5. Conclusion

This project examined how Águas do Tejo Atlântico can embed ESG into its organisational structures, governance arrangements, and strategic practices. The aim has been to identify gaps and shortcomings in their current practices, particularly in relation to governance, performance management, and sustainability reporting, to therefore suggest recommendations for improvement from an ESG perspective. Integrating ESG into decision making processes and corporate culture, rather than treating it as a standalone compliance exercise, has been a central focus of this project.

For AdTA themselves, the team created three documents aimed to support AdTA's internal reflection on their ESG maturity, enabling valuable insights to be gathered along the journey.

These documents included:

1. A structured report outlining the strategies, challenges, and impacts of ESG adoption, including benchmarks from other sectors.
2. A qualitative and quantitative analysis of how different companies implement ESG and its effects on financial performance and reputation.

Group part

3. A deep dive into ESG best practices in the water management and sustainability sector, identifying key lessons for AdTA.

Feedback from AdTA highlighted that the greatest value of the project lay in governance, data management, and reporting readiness rather than technical redesign. Furthermore, a somewhat lack of clarity from the organisation over exact goals or targets from the project left the scope relatively broad, forcing the analysis to focus on identifying main issues and suggesting strategic recommendations rather than detailed implementation plans. Instead, the project emphasised creating a strategic ESG integration roadmap for AdTA so that they may identify foundational enablers for initiatives that are heavily technical or require large investments to be successfully implemented in the future and with greater ease.

Strengthening the Environmental Performance of Águas do Tejo Atlântico: A Deep Dive into Priorities, Best Practices, and Regulatory Implications to Inform Strategic Decision Making

1. Introduction

The following section examines the four environmental priority areas identified within the scope. Recognised as strategically significant for AdTA, these areas collectively represent most of the environmental pressures faced by the company, whilst also offering the most material opportunities to mitigate risk, improve efficiency and to create long-term value.

This focus aligns with the European Commission's renewed emphasis on water resilience. The new *European Water Resilience Strategy*, places water security, sustainable water management and pollution prevention at the centre of environmental, economic and competitiveness policies across its Member States (European Commission 2025). To support this strategy, a biannual Water Resilience Forum will monitor progress and drive coordinated action at EU, national and sectoral levels. Therefore, AdTA's prioritisation of these environmental areas reflects both regulatory expectations and the growing importance of water and ecosystem resilience as strategic business considerations.

A structured review of academic literature is undertaken with some complementary insights, and support from real world case studies, to identify best practices for improvement in these areas. Furthermore, to ensure alignment and plausibility between the literature's suggestions and the current regulatory landscape faced by AdTA, an evaluation of applicable regulatory frameworks has been conducted. The objective of this work is to provide evidence that the strategic recommendations proposed in Section 5 are coherent and actionable.

2. Wastewater Reuse

Water scarcity is an increasingly pressing issue faced by our societies due to population growth, industrialisation, urbanisation, agricultural activities and climate change (Mannina et al. 2022).

By 2030 global water consumption may grow to roughly 160% of the volume we have currently available (Abou-Shady et al. 2023). The Climate ADAPT platform, a partnership between the European Commission and the European Environment Agency (EEA), highlights “an adequate supply of water” to being central in our ability to truly achieve a sustainable future (Climate – ADAPT 2024). Moreover, the United Nations SDGs identify “access to water and sanitation for all” as one of their 17 Sustainable Development Goals (SDGs) and many highlight this SDG as being one of the most important due to reliance of many of the other SDGs on its fulfilment (United Nations 2015) (Seven Seas Water Group 2023).

Regions subject to water shortages and stress are having to increasingly rely on using treated wastewater for purpose, and globally the need for this is only going to increase. Strong attention is already being paid to this in areas such as the middle east who are already experiencing water scarcity issues (Tzanakakis et al. 2023). In fact, many cities are already adopting methods to reclaim and reuse wastewater, ensuring that their residents have a more stable supply (Silva 2023). However, out of the roughly 400 km³ of wastewater that is created globally each year, it is estimated that less than 20% of is treated with a far smaller percentage is being purposefully reused (Christou, et al. 2024).

Treated wastewater has many uses that can reduce stress on potable water resources. These include uses in agriculture, irrigation, industrial cooling, toilet flushing, firefighting and cleaning. In Israel, “more than 90% of treated wastewater effluents are reused” showing that it is feasible (Tzanakakis et al. 2023). However, there are many barriers that can prevent increasing wastewater re-use rates (Mishra, et al. 2023). Initiatives often require economic investment for new infrastructure and the need to prove future returns on investment to show such a project is financially feasible to investors (Sowby 2023). Additionally, careful planning and monitoring is often required, to ensure regulatory compliance and manage risk factors (Lemfarrak et al. 2025).

Best Practices

Strategic and Governance Requirements for Reuse Expansion

Effectively expanding reuse rates of wastewater requires coordinated improvements in planning, operational management, monitoring, and stakeholder engagement (Tzanakakis et al., 2023). This means that utilities, regulators, communities, and other sectors should work together in a coherent way using targets and monitoring systems. Reuse should be embedded within a holistic governance framework where treated wastewater is recognised as a strategic resource that can aid in the progress towards environmental, social, and economic sustainability. Integrating reuse with circular-economy roadmaps ensures that water and waste management utilities can evolve beyond the current linear disposal models to instead take advantage of the benefits of reuse, as well as, nutrient recovery, and reduced emissions (Mannina et al. 2022). Globally, countries are developing and evolving national reuse strategies and quantitative targets, reinforcing this idea of an integrated approach across key stakeholders (Lemfarrak et al. 2025). In a large-scale wastewater reuse project in Brazil, Veolia demonstrated that when carefully planned around reliable and large-scale users, alongside being supported by clear municipal agreements, wastewater reuse can grow successfully (Veolia 2024e).

Monitoring, Indicators, and Operational Performance Management

To operationalise reuse, there is a need to adopt well-defined performance indicators and process controls (Tzanakakis et al. 2023). Beyond just total reuse volumes, indicators such as sectoral allocation, reuse pathways, and microbiological and chemical standards compliance are highlighted as essential metrics for reuse systems to adequately manage social and environmental risks. Operational drivers such as the scale of WWTPs, quality of maintenance, staff capabilities, and energy use also predict reuse performance and therefore can be turned into KPIs to help guide managers in efficiency improvements (Amaral et al. 2023). Milan's San Rocco and Nosedo WWTPs, consistently track reuse volumes and water-quality to ensure

strength through trust between themselves, regulators, and reuse clients enables high reuse rates via clear indicators that focus on outcome (D'Anna 2023).

Technological and Risk-Management Requirements

Advanced treatment technologies and rigorous risk management can also enable the achievement of reuse rates that are both high and safe. Silva (2023), highlights the importance of microfiltration, ultrafiltration, nanofiltration and similar advanced processes to ensure consistent output quality. Simultaneously, the necessity of continued surveillance and strong quality assurance is apparent as when treatment or monitoring is inadequate, significant risks from pathogens and contaminants can arise (Yahaya et al. 2023; Kesari et al. 2021).

Cooperative and Social Acceptance

Finally, wastewater reuse expansion is fundamentally dependent on cooperative governance and social acceptance. Case studies across various countries show that reuse systems, especially those involving agriculture, heavily rely on the need for utilities, regulators, farmers, and municipalities to work together for the system to be successful (Kokkinos et al. 2022; Mannina et al. 2022). This collective action allows for incentives to be aligned and trust to be built across stakeholder groups whilst also ensuring standards are clarified such as the required water qualities, required monitoring and reporting methods, safety standards, and designating responsibilities. Therefore, reuse must be look at as a collaborative process involving multiple actors and key stakeholders which requires open and transparent communication, risk management to be shared, and for there to be close coordination between all involved organisations. The close coordination between the San Rocco and Nosedo WWTPs in Milan and agricultural users of their wastewater enabled them to create a reuse system driven by demand, resulting in generally high acceptance rates for reusing wastewater from those stakeholders (D'Anna 2023).

3. Enhancing Energy Efficiency and the Transition to Clean Energy

Climate change, non-renewable resource depletion and supply concerns, alongside increasing energy consumption and demands has meant that new energy savings strategies are urgently needed (Farghali et al. 2023). While providing essential services for their communities, the energy use from potable water and wastewater utilities accounts for up to 3% of global energy use (Sowby 2023). However, WWTPS can also play a key role in creating a more sustainable future. The landscape of WWTPs is changing “moving towards a more integrated approach which emphasizes resource recovery and attaining net-zero carbon conditions” (Tsalas et al. 2024). However, long-term planning and decision making for strategic investments need to be backed up by strong control systems and data bases to ensure managers and teams have a clear understanding for effective decision making and operational progress.

Best Practices

Benchmarking as the foundation

Benchmarking is highlighted as the foundation of managing energy efficiency. A framework for wastewater treatment plants to improve their energy efficiency, offers guidelines on how best to benchmark via choosing the most appropriate methods based on the WWTP’s needs (Longo et al. 2023). Improving energy efficiency at WWTPs requires managing many different stakeholders and ensuring that each group is receiving the appropriate information to ensure everyone is aligned. This requires building a strong foundation of data and using appropriate methods for specific needs. Clear identification of the goals and purpose of the assessment is required as each may call for different methods. There is also a need to match the chosen method to the type of data available at the WWTP in question as each approach may require varying data needs. The method chosen must also enable useful and understandable outputs for stakeholders involved so that they can effectively communicate to other stakeholder groups,

making the progress more actionable and obtainable. Failure to do so will result in the receiving audience being unable to interpret or understand insights, making them of little use. Therefore, finding an appropriate balance of sophistication for accuracy but simplicity for transparency is vital to achieve practical day-to-day use. Regulatory requirements and long-term strategic also need to influence selection. Each method varies in its levels of detail, standardisation and diagnostic depth. Should there be a strong need to improve long-term decision making, then methods should be chosen that provide more data-intensive tools for planning future upgrades, for example, or replacing major equipment. Veolia used systematic energy benchmarking to inform operational and investment decisions to great effect across treatment processes at the La Farfana “ecofactory” in Chile (Veolia 2025a).

Indicators

Combined with the appropriate benchmarking method(s), normalised and robust indicators such as kWh/m³ treated or kWh/kg pollutant removed allow for inefficiencies to be identified and performance to be fairly compared across plants (Tsalas et al. 2024). Since most energy consumption occurs through aeration, pumping and sludge treatment, process-level indicators are particularly important. Therefore, stage specific tracking should become a prerequisite for targeted energy optimisation.

Digitalisation and the enhancement of organisational capabilities

Multiple reviews of energy saving strategies note that using data-driven models, algorithms for dynamic optimisation, and simulation tools for a sophisticated control of aeration and pumping systems, can significantly improve the capacity to optimise energy performance at utilities (Tsalas et al. 2024) (Farghali et al. 2023). Digital tools enable easier participation in spot markets or demand response programmes for energy, even as markets become more dynamic, through the likes of real-time monitoring and flexible load management (Lima et al. 2023; Sowby 2023).

Organisations require structured energy-management systems to sustain improvements (Sowby 2023). This includes regular audits, effective management of energy related data management, staff training and engagement, and the creation of clear performance goals. However, many utilities are hindered by gaps in major skills, particularly data analysis and energy auditing, therefore further highlighting the need for training and cross-functional collaboration in achieving improved energy efficiency and reducing the negative externalities from high energy needs of WWTPs (Wilson et al. 2021).

4. Biodiversity and Ecosystem Stewardship

Human's have settled near to and benefitted from freshwater ecosystems for thousands of years for our survival, however our reliance on these ecosystems has also led to their decline. Biodiversity in approximately half of the world's rivers has been weakened or damaged through human activities and populations of freshwater species are declining by 3.9% each year, almost four times faster than the populations of land animals at 1.1% annually (Haase et al. 2025; Reid et al. 2019). Since 1970, on average there has been an 85% fall globally in freshwater vertebrate populations (Tickner et al., 2025; WWF, 2024). Furthermore, "24% of the world's freshwater fish, dragonfly, damselfly, crab, crayfish and shrimp species are at high risk of extinction" (IUCN 2025). The harm inflicted results from wastewater discharge, water removal, the alteration of channels and flows, and chemical runoffs, particularly in densely populated regions (Haase et al. 2025). Therefore, it is imperative to change the current narrative, creating a future that allows us and the ecosystems we rely on to thrive. Whilst the effort cannot be left to singular entities but rather should be collective, it is still vital to highlight the role water utilities play in being able to executive effective change.

Operationally, utilities offer both causes and solutions for the decline of freshwater ecosystems. Outdated or failing infrastructure can release nutrients, pathogens, pollution, and toxins into wetland and river habitats that can fuel harmful algal blooms, reduce oxygen levels, spread

diseases, causing the degradation or collapse of these ecosystems (Cunningham and Gharipour 2018). Simultaneously, utilities have an opportunity to play a role in effective biodiversity recovery as they operate at the so-called catchment scale. Failing to match conservation actions to the scale of impacts geographically, limits the effectiveness of the action's outcomes (Haase et al. 2025). Therefore, utilities have a unique opportunity to protect ecosystems and lessen impacts at a wider scale, and it is paramount that they do so. Failure to integrate ecosystem stewardship into AdTA's core strategies will negatively impact the health of the communities they serve, result in penalties from regulators, and cause increased treatment costs in the long run due to declining water quality (Cunningham and Gharipour 2018; Tickner et al. 2025).

Best Practices

Collaboration and the Need for a Systemic, Catchment-Scale Governance Approach

A systemic, catchment-scale approach is as a necessity for effective stewardship (Tickner et al. 2025). Coordinated governance across sectors at the catchment level is crucial in stopping the degradation of ecosystems. Evidence shows that catchment scale interventions combining legislation, stakeholder engagement and strategies to manage species has a greater impact potential than isolated measures by entities acting individually (Haase et al. 2025). In the case of Milan, referring to the San Rocco and Nosedo WWTPs once more, reuse planning extends to also support wetlands, meadows, and recreational landscapes, demonstrating that catchment-scale coordination can generate wider ecological and social benefits (D'Anna 2023).

Outcome-Based Monitoring

Implementing rigorous, outcome-based monitoring frameworks is also recommended due to traditional compliance-based monitoring failing to capture whether actions are improving biodiversity. Therefore, monitoring should aim to measure ecological responses such as the number of species, diversity levels amongst them, how they recover and adapt from

disturbances resulting from overflows or leakages and generally look to support better decision-making long term (Haase et al. 2025). RecoLab, a self-proclaimed “development facility” for wastewater treatment in Sweden, uses a linked outcome-based approach explicitly measuring factors such as reduced nutrient discharge or energy saved per unit of nutrient removed to showcase clear multifaceted improvements (RecoLab 2021).

Internal Controls, Transparency, and Engagement in Water Governance

The use of strong internal controls and environmental-management systems, such as ISO 14001, help to ensure clear responsibilities, the identification of systematic impacts and continuous improvements, all of which enable environmental protection to be operationalised and positive biodiversity outcomes to be achieved (Herrera-Navarrete et al. 2022). Transparency here is also vital. With performance being visible, transparent oversight motivates utilities to improve their own monitoring controls, targets and investments (Mu et al. 2025). Action is motivated from within which therefore leads to improved biodiversity management without relying on external actors. Utilities therefore also benefit from similarly transparent practices in their reporting and engagement with other actors in regional water governance (Koop and van Leeuwen 2017). Águas do Vale do Tejo (AdVT), another umbrella company of Águas de Portugal, has demonstrated a more developed and transparent approach to their engagement with biodiversity initiatives, highlighting that AdTA’s current reporting gaps are not unavoidable in this regulatory and institutional context (AdVT 2025).

5. Sludge Valorisation and Circular Resource Pathways

The treatment and disposal of sludge accounts for around 50% of the operating costs at a conventional wastewater treatment facility (Samberger et al. 2024). Despite their being numerous methods and technologies to recover the valuable nutrients and organic material it holds, sludge is still commonly disposed of by utilities. This can be considered a paradox, when you look at the valuable circular opportunities that can be obtained from the properties of the

sludge. Furthermore, it's mismanagement factors into degrading water bodies (Nadir and Ahmed 2023). Highlighted by the conflict between Russia and Ukraine, energy security and self-sufficiency are becoming increasing concerns, pushing the attention of many countries to explore the potential of Biogas and Biomethane, especially at WWTPs, that will enable them to create more circular economies (IEA 2025a). This outlines the importance of WWTPs maximising the potential of sludge to make effective strides towards more circular and sustainable operations in the long run.

Best Practices

Biogas, Biomethane, and Circular Resource Management

WWTPs can generate biogas from sludge and even upgrade to the production of biomethane to allow for injections of energy into the grid, or the creation of cleaner transport fuels that can be used internally in operations or sold externally (Nguyen et al. 2021; Rodrigues et al. 2025). Biogas is a renewable energy source that is produced by breaking down organic wet material without oxygen being present, a process called anaerobic digestion. The Biogas produced is typically made up of roughly 60% Methane and 40% Carbon Dioxide (IEA Bioenergy 2022). Biomethane is essentially a more purified form of Biogas with more of the Carbon Dioxide removed leaving it to become roughly over 90% methane. Due to the varying purity levels, the two are not fully interchangeable; however, both can be used as renewable energy sources and support circular economy systems.

The large amount of wet organic material collected through operations and treatment make WWTPs ideal facilities to produce Biogas and Biomethane (Nguyen et al. 2021). This can enable them to not only cover their internal energy requirements, becoming self-sufficient, but also to create revenue streams through selling on their surpluses.

From an ESG standpoint, maximising a WWTP's Biogas/Biomethane production and use will reduce or perhaps even entirely eradicate the need to use fossil fuels whilst also lowering the

level of methane leaks from uncontrolled sludge disposal, therefore cutting the plants Scope 1 emissions (Lima et al. 2024). Furthermore, it enables the plants to improve their resource circularity, saving costs, increasing resilience, and providing new streams of revenue as seen in La Farfana wastewater treatment facility where sludge digestion for nutrient and energy recovery is fully integrated into the plant's operations (Veolia 2025a).

Agricultural Reuse as a Complementary Valorisation Strategy

Biosolids from sludge, when managed safely, can deliver multiple benefits to soil health and play a valuable role in regenerative agricultural systems. Portuguese topsoil organic matter levels are generally very low. In 2014, a study found that roughly 70% of Portuguese soils contain less than 1% of organic matter which is considered very low, and that only 27.5% contained over 2% organic matter which is considered acceptable for many agricultural systems (Carvalho and Lourenço 2014). However, research has identified that municipal biosolids can significantly improve soil health across agricultural and urban environments, creating an additional route for sludge to be used and for utilities to capture value and benefits (Brown et al. 2020). An opportunity is therefore presented to form mutually beneficial agreements with farmers by aligning the reuse of sludge and biosolids with the agricultural sectors broader sustainability and productivity goals. However, case studies show that a combination of robust standards, institutional capacity, and public acceptance, are needed to successfully reuse sludge (Kokkinos et al. 2022). Therefore, the importance of regulatory clarity and coordinated stakeholder engagement cannot be understated.

Safeguarding Public and Environmental Health Through Monitoring and Training

Rigorous monitoring and strong operational controls is required to enable effective sludge valorisation through safeguarding the public from contamination and disease (Yahaya et al. 2023; Kesari et al. 2021). Ongoing training is also essential to ensure that sludge is handled, treated and applied in accordance with safety standards and regulatory requirements to mitigate

such risks (do Monte 2007; Yahaya et al. 2023; Kesari et al. 2021). Furthermore, robust monitoring systems not only protect public health but also reinforce confidence in sludge reuse initiatives among stakeholders and regulators.

6. Regulatory Implications for AdTA: Looking at Portugal's Decree-Law 119/2019 and the EU's Water Framework Directive to strengthen strategic recommendations

Portugal's Decree-Law 119/2019 outlines that every reuse project must undergo a full ISO-aligned health risk assessment, environmental risk assessment, a fit-for-purpose quality assessment, and the selection and justification of multi barrier configurations (Rebelo et al. 2020). Therefore, AdTA's approach to reuse must shift to evidence-based, formally documented planning, requiring better data systems, technical expertise, structured stakeholder collaboration and the capacity for long-term monitoring. An emphasis is put on matching water utilities with users to reduce costs and disruption to pipelines, requiring a more systematic approach as intuition or opportunistic contracts can no longer be relied upon. Instead, it must be data driven. AdTA must also implement continuous monitoring, plans for risk management, periodic reassessments, and documented compliance with quality standards to meet the legislation's stricter monitoring and reporting requirements.

Whilst focusing primarily on reuse, the recent legislation (Decree-Law 119/2019), has several implications affecting the energy strategies of water utilities. The need for treatment to be fit-for-purpose will likely increase energy consumption as producing higher classes of water (Class A, or A+) requires higher levels of energy for increased filtration, disinfection, and even more advanced processes in some cases. Unless this increased consumption of energy can be offset internally, it will inevitably increase WWTPs operational energy consumption. Energy optimisation, therefore, becomes intertwined with reuse expansion.

Beyond the water-treatment processes themselves, the law recognises other methods for reducing risks and improving safety around wastewater reuse. Drip irrigation can be used to avoid crop contamination, buffer zones to keep the public away from irrigation areas, or application restrictions can be imposed to help minimise exposure. This may allow for more cost-effective and energy-efficient schemes. However, collective action and engagement across all basin actors is needed moving forwards to address issues that remain unresolved such as agricultural pollution (Albiac et al. 2024).

The EU's WFD puts a strong emphasis on ensuring that receiving water bodies aren't harmed through the reuse of wastewater requiring the assessment of environmental risks that considers nutrients, contaminants, microbiological hazards and priority substances (Nadir and Ahmed 2023). This requires utilities to improve their monitoring of effluent qualities, track ecosystem health, implement KPIs for the quality of rivers and coastal waters, and record corrective measures implemented to address overflows or operational failures. Furthermore, greater transparency on these efforts is required. This links biodiversity stewardship with wastewater reuse as well as energy consumption. Embedding biodiversity into operational planning for water utilities must therefore be done to ensure effective management of overflows, sludge, water discharges, and reuse projects near sensitive ecosystems.

Whilst not directly regulating sludge, this decree influences the strategy around it. Since wastewater reuse projects must consider nutrients and pollutants to protect water bodies, it creates an opportunity to remove and valorise these nutrients prior to the project. Therefore, wastewater reuse can facilitate value creation for utilities through the extraction of valuable nutrients, meaning that utilities can support their circularity goals in these two areas simultaneously. The interconnectedness, highlighted between the different environmental areas in the scope, shows a clear need for an integrated approach at AdTA, where information exchange and transfer can be done with ease to ensure strong decision making.

7. Conclusion

The demands for robust monitoring, evidence-based planning, biodiversity protection, energy conscious treatment and circular-resource management from the legislation clearly shows the need to embed environmental and social metrics into the core strategy and financial decision-making of AdTA. A unified, performance-based KPI framework alongside standard measurement systems will be required to ensure consistent and transparent evaluation of environmental performance across sites. Digital tools, able to automate data collection, enhance accuracy and support timely reporting, are needed to meet the scale and complexity of the monitoring requirements expected through both Decree-Law 119/2019 and the EU's WFD. Internal controls must be strengthened by AdTA via formalising procedures, validation mechanisms, and systems for evidence-tracking to certify the integrity of their environmental data. Furthermore, the emphasis put on the need for collaboration by the legislation accentuates the importance of strategic partnerships and active stakeholder engagement to achieve environmental improvements. Ongoing development of staff competencies via cross-functional training and collaboration will also be required to ensure that teams understand new KPIs, data systems, operational protocols, and legislative requirements. In doing so, AdTA can co-manage multiple environmental areas simultaneously, enabling them to design and implement integrated strategies for measurable operational improvements across several environmental areas at once.

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