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CASE STUDY

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Circular economy: On the road to ISO 59000 family of standards

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Abstract

The article aims to analyse the experience regarding the adoption of the voluntary French standard XP X30-901, used as the main reference point to design the ISO 59004 that will define the terminology, principles and guidance to provide a common understanding of the circular economy. After an analysis of its structure, based on a case study conducted in a pioneering company, the study provides an innovative contribution to the understanding of the adoption of Circular Economy Project Management Systems by companies to move towards CE through XP X30-901, explaining the main drivers and barriers, the standard's adoption process and the effects in the results. The main enabler is considered its experience working with an integrated management system. The adoption has helped to integrate actions to improve the indicators of the seven areas considered by the standard: Sustainable Sourcing, Eco-design, Industrial Symbiosis, Functional Economy, Responsible Consumption, Extending Lifetime and Efficient Management of Materials at the end of life. Overall, the company appears to be satisfied with the adoption, mainly, because it has helped it to structure actions to improve its circularity indicators. However, the need for capital to develop the investments has been the most important barrier.

KEYWORDS

circular economy, ISO 59004, life cycle, project management system, sustainability, XP-X30 901

1 | INTRODUCTION

Considering the growing impacts that the current development model is having on the planet's ecosystems, one of the greatest challenges facing humanity in the future is the sustainable management of natural resources (George et al., 2018). To achieve this goal, the development of a circular perspective, not only at the social and governmental level but also at the business level, becomes necessary (Mazzucchelli et al., 2022). Indeed, the business world has begun to implement the circular economy (CE) as an economic model for sustainable development capable of ensuring business competitiveness through a profound transformation of business models and production processes (Bjørnbet et al., 2021).

The progress of this CE model requires the development and application of new mandatory regulations, such as the European taxonomy, in order to bring structure to the transformation process (Triguero et al., 2022). Specifically, EU Regulation 2020/852 (European Parliament and Council EU, 2020) regulates a common

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classification system to identify economic activities considered environmentally sustainable as defined by the European taxonomy in response to current climate and environmental challenges. It contributes to the aim of the European Green Deal by referring to six environmental objectives, one of it is to facilitate the transition process towards the CE, in order to increase transparency and consistency in the classification of these activities and to limit the risk of 'greenwashing' (Wang et al., 2022). This regulation requires certain companies to publish climate-related key performance indicators. In particular, information on the proportion of turnover of such large non-financial companies, their investments in fixed assets or their operating expenditure associated with environmentally sustainable economic activities (Moneva et al., 2022). In addition, the future requirement of the European digital product passport by the European Commission will be an aspect that companies that want to sell their products in the European Union will have to comply with (Nyvall et al., 2022). This will oblige the entire supply chain in certain sectors to provide environmental information. In a first phase, from 2026, it is expected to affect the battery, electrical and electronic products and textile sectors, but later it will be extended to other sectors (European Commission, 2022).

In addition, many initiatives directly related to areas of action of the CE have been conducted to accelerate the change of paradigm (Ghosh, 2020). Among others, the growth of global supply chains fostered the adoption of voluntary management standards as a regulatory mechanism to respond to stakeholder concerns (Büthe & Mattli, 2011; Fonseca et al., 2022). In addition to the most widespread management standards, ISO 9001 (Quality Management System—Requirements) and ISO 14001:2015 (Environmental Management System: Requirements with Guidance for Use), some management tools have been promoted in different areas of action of the CE. Ecodesign, industrial symbiosis, functional or service economy (product-service systems), responsible consumption, an extension of duration of use, efficient management of end-of-life products and materials can be highlighted (Arana-Landin et al., 2012; Blomsma & Brennan, 2017; Fitch-Roy et al., 2020; Ruggieri et al., 2016; Savini, 2021). Some of these systems can be audited and certified by independent external certification bodies that, by performing a third-party audit, assess whether the applicable system complies with the applicable standard and achieves the intended results (Fonseca et al., 2017).

However, the conceptualisation of the CE is not uniform in these initiatives (Friant et al., 2020; Lakatos et al., 2021). All of them emphasise the systematisation of the maximum use of existing natural resources and the reduction of waste (Lacy & Rutqvist, 2015; Savini, 2021). After all, it seems that the integration of a circular perspective is an obligatory step towards a development model focused on maximising the reuse of available or transformed natural resources (Ghosh, 2020). We should mention the standardisation of environmental management systems and energy efficiency (ISO 14001, 2015; ISO 50001, 2018), ecodesign (ISO 14006, 2020), the carbon footprint of products, services and organisations (ISO 14064-1, 2018; ISO 14067, 2018), environmental labels and declarations series (ISO 14020, 2000), or even the standards that regulate the methodology for the environmental assessment of a product's life cycle analysis (ISO 14040, 2020).

Nevertheless, although this debate has been going on for more than two decades (Schöggl et al., 2020), a specific international management standard for the CE is not yet available. Some smaller initiatives at national level, such as BS 8001:2017—Framework for implementing the principles of the circular economy in organisations. Guide—(British Standards Institution, 2017) or the French standard XP X30-901—Circular economy—Circular economy project management system (CEPMS)—Requirements and guidelines—(AFNOR, 2018), are considered reference standards to evaluate circularity (Poponi et al., 2022).

The standard BS 8001:2017 is a framework for the application of the principles of CE in organisations, developed by the British Standard Institution (BSI) in 2017 (see Table 1). It guides organisations in the implementation of the principles of the CE to improve the management of their resources. The standard offers a methodology to develop, at least partially, a CE perspective, based on the following six principles (BSI, 2017):

1. Systems thinking: Understanding the system-wide impacts of your activity.
2. Innovation: Rethinking resource management as a lens for value creation.
3. Stewardship: Taking responsibility for the ripple-effect impacts resulting from your decisions and activities.
4. Collaboration: Securing system-wide benefits by cooperating with others.
5. Value optimization: Keeping materials at their highest value and function.
6. Transparency: Being open and honest about circular barriers and benefits.

Also in Europe, the Association Française de Normalisation (AFNOR) has developed the French standard XP X30-901 (AFNOR, French Standard Institute, 2018). The definition of this voluntary standard has been influenced by the BS8001 standard (Kafel & Nowicki, 2022). In addition, by the end of 2022, the experimental technical standard UNI/TS 11820:2022 'Measurement of Circularity—Methods and Indicators for Measuring Circular Processes in Organizations' was published by the Ente Italiano di Normazione. It shown a panel of 71 indicators for the assessment of the circularity in organisations (UNI, Ente Italiano di Normazione, 2022) and complement other measurement systems based on circular economy indicators. For example, those developed by the Ellen MacArthur Foundation (Ellen MacArthur Foundation, 2015, 2019) and the European Commission (Commission of European Communities, 2014, 2015; Mazur-Wierzbicka, 2021).

Due to the need for international standards, in 2018, ISO created the ISO/TC 323 'CE' technical committee. France's role in this committee is very relevant as it was founded thanks to a French initiative (Poponi et al., 2021). AFNOR currently holds the presidency of this committee and the French standard XP X30-901 is the main working basis of this committee. The ISO/TC 323 committee is composed of 71 participating and 14 observing members, and it aims to achieve standardisation in the CE field to develop frameworks, guidance, supporting tools and requirements for the implementation of activities of all organisations involved, to maximise the contribution to Sustainable

TABLE 1 Comparison between BSI 8001 and XP X30 901 standards.

Factor	BS8001:2017	XP X30-901
Aim	Framework and guidance	Requirements and guidelines
Application	Any organisation	Circular Economy project Management System in an organisation
Phases	1. Framing 2. Scoping 3. Idea Generation 4. Feasibility 5. Business case 6. Piloting and prototyping 7. Delivery and implementation 8. Monitor, review and report	1. Leadership, commitment, policy, roles and responsibilities. 2. Plan, reference situation review, defining a strategy and action plan. 3. Do: implementation and monitoring of action plans. 4. Check: assessment of results 5. Act improvement
Main fundamentals	Six principles: 1. System thinking 2. Innovation 3. Stewardship 4. Collaboration 5. Value optimization 6. Transparency	Seven areas of action: 1. Sustainable procurement. 2. Ecodesign. 3. Industrial symbiosis. 4. Functional or service economy. 5. Responsible consumption. 6. Product lifetime extension. 7. efficient management of end-of-life product and materials
Dimensions	Economic Environmental Social	Economic Environmental Social
Circular economy definition	'An economy that is restorative and regenerative by design, and which aims to keep products, components, and materials at their highest utility and value always, distinguishing between technical and biological cycles'	Economic system of exchange and production, which, at all stages of the product (goods and services) life cycle aims to use resources more efficiently and diminish the environmental impact while fostering individual wellbeing, and in which the value of the products, materials and resources is maintained in the economy for as long as possible and waste production is minimised.
Certification	It is not intended nor suitable for certification purposes.	Certification is offered by AFNOR

Source: Own elaboration based on BSI 8001 and XP X30 901 standards.

Development. It works in cooperation with existing committees on subjects that may support CE (Perissinotti Bisoni et al., 2020).

The future ISO 59000 series are still under development, and it is expected to finish the publication of the collection in 2024. The main norms are (Chevauche, 2022):

1. ISO WD 59004—CE—Terminology, Principles and Guidance for implementation: The aim is to provide a common understanding of the CE. It is based on the creation of an economic system that uses a systemic approach to maintain a circular flow of resources by regenerating, retaining, or adding to their value, while contributing to sustainable development.
2. ISO WD 59010—CE—Guidance on business models and value networks: It provides guidance for an organisation seeking to transition its business models and value networks from linear to circular.
3. ISO WD 59020—CE—Measuring and assessing circularity: It specifies a framework for organisations to measure and assess circularity, enabling those organisations to contribute to sustainable development.
4. ISO WD 59040—CE—Product Circularity Data Sheet. It is intended for certification purposes and provides a general methodology for defining, implementing, operating, monitoring, reviewing, maintaining, and improving Product Circularity Data Sheets when acquiring or supplying products.
5. ISO WD 59014—Secondary materials—Principles, sustainability, and traceability requirements. It is being designing by Technical Committee 207 but it will follow the principles of the future ISO 59004.
6. ISO TR 59031—CE—Performance based approaches and ISO TR 59032—CE—Review of business model implementation. They are supporting documents. Their role will be to provide experience-based information to make the circular economy tangible and concrete.

The interest among companies is growing (Poponi et al., 2021). In fact, as it is foreseeable that the international ISO 59004 will be largely based on one of the two standards, there are companies that have taken the plunge and adopted the guidelines of one of the current standards. It is particularly interesting to learn about the adoption process of these companies, as the lessons learned can be of great value to other companies as they embark on this journey.

Regarding certification, AFNOR has published an evaluation guide (AFNOR, 2018) that AFNOR certification uses to differentiate in its certificates the level reached in the adoption of CEPMSs by companies (initial, confirmatory, exemplary). However, other certifiers do not specify it in the certificates, nor do they include their accreditation record to issue this kind of certification. This is not covered in the standard. However, it is included in other international standards, such as ISO 9001 and ISO 14001, and accredited bodies include in their certificates their registers of accredited companies. Taking these aspects into consideration, the aim of this article is to analyse how companies have adopted the XP X30-901 standard. Specifically, an attempt is made to answer to the following key research questions (RQs):

RQ1. What are the main drivers and barriers for companies to move towards CE through XP X30-901?

RQ2. What are the main actions developed by companies to move towards CE by adopting XP X30-901?

RQ3. What are the main CE results achieved by companies by adopting XP X30-901?

Considering these RQs, the article has been structured as follows.

After this introduction, the structure and content of the standard is outlined. In Section 3, the literature review is presented. In Section 4, the research methodology applied is described. In Section 5, the case study carried out in an Italian company is analysed. Section 6 contains the discussion and conclusions of interest to those groups involved in the adoption of CE standards. Finally, references are provided in the final section.

2 | THE XP X30-901 STANDARD

The standard XP X30-901. CE—CEPMS—Requirements and Guidelines was approved by AFNOR in 2018. The standard aims to determine terms, principles, practices, requirements, and recommendations for developing CEPMSs. It promotes a common understanding of the CE and includes requirements for planning, implementing, evaluating and improving a CEPMS, using an open and holistic approach (AFNOR, 2018). It provides a systematic focus in the three dimensions of sustainable development (environmental, economic and social) and in the seven areas of action: Sustainable supply, Ecodesign, Industrial symbiosis, Functional economy, Responsible consumption, Extension of duration and Effective management of end-of-life materials or products (AFNOR, 2018).

The main objective of XP X30-901 is to facilitate dialogues to reflect on both modes of production and modes of consumption through a common language and shared definitions. It is expected to have a positive impact on the efficiency of organisations that carry out actions resulting from the implementation of the standard to optimise the use of their resources and limit the waste generated (AFNOR, 2018).

The structure is based on the High-Level Structure model of the ISO standards and fulfils the universal management requirements providing a management tool to plan, implement, evaluate and improve a CE project (PDCA cycle) (Nowicki et al., 2020). Like other ISO standards that follow this model, the first three sections of the structure develop: (1) The definition of the standard scope; (2) The normative references; and (3) The terms and definitions used. The rest of the sections of the structure are shown graphically in Figure 1.

'ANNEX A—(informative) Examples of questions for each area of action' provides a system of questions to obtain CE improvements at each stage of the continuous improvement process. This structure includes performance requirements that must be fulfilled to achieve compliance with the standard and to obtain better CE results (Benady et al., 2020). It is focused on projects and designed for all types of organisations. Many of the areas developed in XP X30-901 are already included in other standards and initiatives. However, it is the unique that provides a single approach to defining and measuring the management system in the framework of the circular economy model (Homrich et al., 2018; Kirchherr et al., 2017; Masi et al., 2017; Saidani et al., 2019). This framework is expected to help overcome the lack of consensus that inhibits the analysis and comparison of different CE projects and thus help overcome one of the main barriers limiting the adoption of CE models by organisations. (Åkerman, 2016; Kirchherr et al., 2017; Masi et al., 2018; Muradin & Foltynowicz, 2019).

3 | LITERATURE REVIEW

The literature review has been synthesised in three tables. Table 2 shows the main drivers and barriers for companies to move towards circular economy management. Specifically, its structure has been divided into two parts depending on whether their motivations and barriers are linked to internal factors (Business Models, Economic and financial factors, Business policies, strategies and practices, and Internal company resources) or external factors (CE policies and regulation, socio-cultural factors, environmental factors and external resources available to the company).

Among the drivers in relation to internal factors, it is worth highlighting the studies that analyse the opportunities offered by new technologies for the development of management models (Bressanelli et al., 2018; Jabbour et al., 2019; Moktadir et al., 2018; Sehnem, 2019), the possibility of reducing costs and improving profitability (Agyemang et al., 2019; Behrens, 2016; Jensen et al., 2019; Prieto-Sandoval et al., 2018; Rizos et al., 2016), the environmental commitment of companies (Esken et al., 2018; Fortunati et al., 2020; Ormazabal et al., 2018; Prieto-Sandoval et al., 2018; Rizos et al., 2016), their previous experiences in training (Dey et al., 2019; Ilić & Nikolić, 2016; Kristoffersen et al., 2021; Schroeder et al., 2019) and development of circular practices (Chembessi et al., 2022; Cui et al., 2017; den Hollander et al., 2017; Fonseca et al., 2018; Govindan & Hasanagic, 2018; Hagejärd et al., 2020; Konietzko et al., 2020; Linder & Williander, 2017; Moktadir et al., 2020;

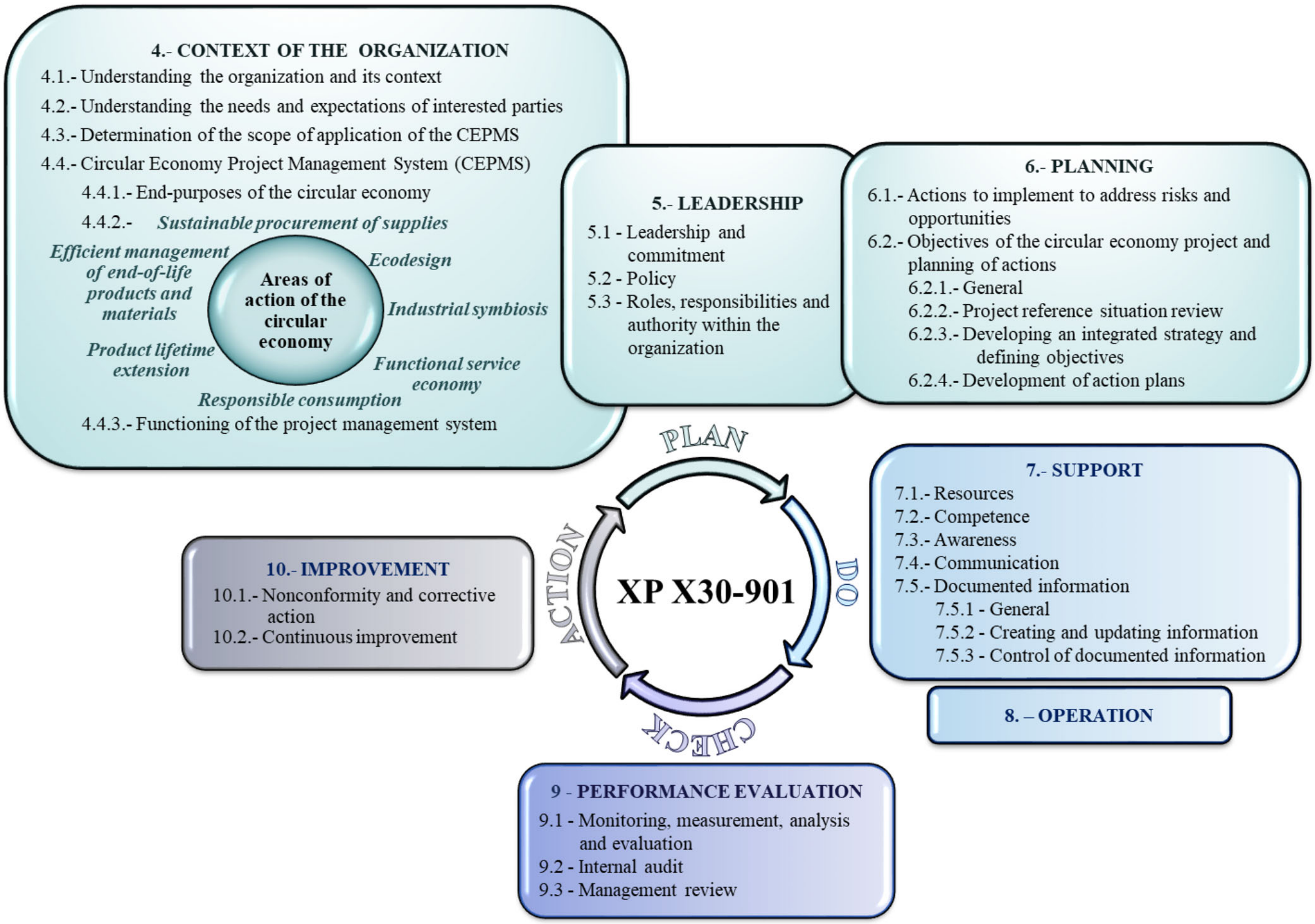

FIGURE 1 Structure of the standard XP X30-901.

Nogueira et al., 2020; Rizos et al., 2016; Sumter et al., 2018; Tura et al., 2019). As for the drivers related to external factors, those related to national and international regulations stand out, as well as their assessment in public tenders (Agyemang et al., 2019; Arana-Landin & Heras-Saizarbitoria, 2011; Arranz et al., 2022; Chembessi et al., 2022; del Mar Alonso-Almeida et al., 2021; Ilić & Nikolić, 2016; Jakhar et al., 2018; Landeta-Manzano et al., 2017; Malinauskaite et al., 2017; Mallory et al., 2020; Milios, 2018; Nudurupati et al., 2022; Oghazi & Mostaghel, 2018; Sousa-Zomer et al., 2018; Urbinati et al., 2021; Wrålsen et al., 2021), the effect it has on the image of the organisation (Ormazabal et al., 2018; Prieto-Sandoval et al., 2018; Rizos et al., 2016) or pressures from external stakeholders, such as, customers or public administration (Agyemang et al., 2019; Gupta et al., 2019; Nudurupati et al., 2022; Ranta et al., 2018; Russell et al., 2020; Veronica et al., 2020).

Barriers linked to internal factors include lack of financial resources for investments (Kazancoglu et al., 2020; Pathak & Endayilalu, 2019), production and waste management costs (Agyemang et al., 2019; Kirchherr et al., 2018; Linder & Williander, 2017), the financial uncertainty generated by the investment (Bocken et al., 2018; Ingemarsdotter et al., 2020; Kumar et al., 2019; Upadhyay et al., 2022; Wrålsen et al., 2021) and those relating to the lack of human resources (Agyemang et al., 2019; Bocken & Geradts, 2020; Cantú et al., 2021; Garcés-Ayerbe et al., 2019; Guldmann & Huulgaard, 2020; Jabbour et al., 2019; Pesce et al., 2020; Werning & Spinler, 2020; Zucchella & Previtali, 2019), technological (Donner & de Vries, 2021; Hopkinson et al., 2018; Jabbour et al., 2019; Luscuere, 2017; Nudurupati et al., 2022; Tura et al., 2019) and material (Cantú et al., 2021; Chiappetta Jabbour et al., 2020; Guldmann & Huulgaard, 2020; Rizos et al., 2016). As for those linked to external factors, the lack of clarity in current regulations and the uncertainty of future legislation stand out (Brunnhofer et al., 2020; Cantú et al., 2021; Casiano Flores et al., 2018; Chembessi et al., 2022; Garcés-Ayerbe et al., 2019; Kirchherr et al., 2017; Kumar et al., 2019; Paletta et al., 2019; Patwa et al., 2021; Rizos et al., 2016; Shao et al., 2019; van Keulen & Kirchherr, 2021; Vermunt et al., 2019), lack of confidence in the quality of circular products (Baxter et al., 2017; Donner et al., 2021; Kirchherr et al., 2018; Ritter et al., 2015) and barriers encountered by companies in the supply chain (Cantú et al., 2021; Despeisse et al., 2017; Fonseca et al., 2018; Guldmann & Huulgaard, 2020; Gupta et al., 2019; Landeta Manzano et al., 2015; Landeta-Manzano et al., 2017; Linder & Williander, 2017; Mishra et al., 2021; Vermunt et al., 2019; Yu et al., 2021).

TABLE 2 Drivers and barriers for companies to move towards CE management.

Factors	Description	References
Internal factor—business models	+ Business models based on digital technologies such as big data analytics and the Internet of Things	Bressanelli et al., 2018; Jabbour et al., 2019; Moktadir et al., 2018; Sehnem, 2019
	—Lack of business model compatibility	Linder & Williander, 2017; Narimissa et al., 2020
Internal factor—economic and financial	+ Possibility to reduce operating costs and increase financial profitability	Agyemang et al., 2019; Behrens, 2016; Jensen et al., 2019; Prieto-Sandoval et al., 2018; Rizos et al., 2016
	—Lack of financial resources to meet the significant investments required	I. Kazancoglu et al., 2020; Pathak & Endayilalu, 2019
	—High production and waste management costs	Agyemang et al., 2019; Kirchherr et al., 2018; Linder & Williander, 2017
	—Financial uncertainty about viability and incentives	Wrålsen et al., 2021
	- Financial uncertainty about the profitability of reused products	Ingemarsdotter et al., 2020
	—Financial uncertainty about investment returns	Kumar et al., 2019; Upadhyay et al., 2022
	—Financial uncertainty about complex commercial transactions	Bocken et al., 2018
Internal factor—business policies, strategies and practices	+ Environmental responsibility of the company	Esken et al., 2018; Fortunati et al., 2020; Ormazabal et al., 2018; Prieto-Sandoval et al., 2018; Rizos et al., 2016
	+ Circular practices in innovation, organisational infrastructure, product research and development	Chembessi et al., 2022; Cui et al., 2017; Den Hollander et al., 2017; Fonseca et al., 2018; Govindan & Hasanagic, 2018; Hagejärd et al., 2020; Konietzko et al., 2020; Linder & Williander, 2017; Moktadir et al., 2020; Nogueira et al., 2020; Rizos et al., 2016; Sumter et al., 2018; Tura et al., 2019
	—Restrictive corporate culture	Kirchherr et al., 2018
	—Organisational and product design factors	Bocken et al., 2016; Bonsu, 2020; Cantú et al., 2021; Guldmann & Huulgaard, 2020; Hobson, 2020; Mendoza et al., 2017; Rizos et al., 2016; Urbinati et al., 2021; van Keulen & Kirchherr, 2021
Internal factor—company resources	+ Availability of material resources	Genovese et al., 2017
	+ Human resources trained, educated and sensitised to CE practices	Dey et al., 2019; Ilić & Nikolić, 2016; Kristoffersen et al., 2021; Schroeder et al., 2019
	+ Internal stakeholders	Chembessi et al., 2022
	—Lack of qualified, trained and sensitised human resources with CE practices	Agyemang et al., 2019; Bocken & Geradts, 2020; Cantú et al., 2021; Garcés-Ayerbe et al., 2019; Guldmann & Huulgaard, 2020; Jabbour et al., 2019; Pesce et al., 2020; Werning & Spinler, 2020; Zucchella & Previtali, 2019
	—Technological barriers	Donner & de Vries, 2021; Hopkinson et al., 2018; Jabbour et al., 2019; Luscuere, 2017; Nudurupati et al., 2022; Tura et al., 2019
	—Lack of material and non-material resources, such as time or communication	Cantú et al., 2021; Chiappetta Jabbour et al., 2020; Guldmann & Huulgaard, 2020; Rizos et al., 2016
External factor—CE policies and regulation	+ National and international policies, such as, taxation, subsidies, public tenders, subsidies or incentive policies	Agyemang et al., 2019; Arana-Landin & Heras-Saizarbitoria, 2011; Arranz et al., 2022; Chembessi et al., 2022; Del Mar Alonso-Almeida et al., 2021; Ilić & Nikolić, 2016; Jakhar et al., 2018; Landeta-Manzano et al., 2017; Malinauskaite et al., 2017; Mallory et al., 2020; Milios, 2018; Nudurupati et al., 2022; Oghazi & Mostaghel, 2018; Sousa-Zomer et al., 2018; Urbinati et al., 2021; Wrålsen et al., 2021
	—Restrictive policies and regulations, for example, on waste use	I. Kazancoglu et al., 2021
	—Lack of clear and effective policies and regulations	Brunnhofer et al., 2020; Cantú et al., 2021; Casiano Flores et al., 2018; Chembessi et al., 2022; Garcés-Ayerbe et al., 2019; Kirchherr et al., 2017; Kumar et al., 2019; Paletta et al., 2019; Patwa et al., 2021; Rizos et al., 2016; Shao et al., 2019; van Keulen & Kirchherr, 2021; Vermunt et al., 2019

TABLE 2 (Continued)

Factors	Description	References
External factor—socio-cultural	+ Increase of the company's prestige	Ormazabal et al., 2018; Prieto-Sandoval et al., 2018; Rizos et al., 2016
	+ Pressure from stakeholders	Agyemang et al., 2019; Gupta et al., 2019; Nudurupati et al., 2022; Ranta et al., 2018; Russell et al., 2020; Veronica et al., 2020
	−Lack of influence and participation among stakeholders	Landeta-Manzano et al., 2017; Winans et al., 2017
	−Lack of confidence in the quality of circular production	Baxter et al., 2017; Donner et al., 2021; Kirchherr et al., 2018; Ritter et al., 2015
External factor—Environ.	+ Shortage of natural resources	Linder & Williander, 2017; Murray et al., 2017; Urbinati et al., 2021
	+ Stakeholder environmental responsibility	Chiappetta Jabbour et al., 2020; D'Agostin et al., 2020; Linder & Williander, 2017; Šebestová & Sroka, 2020
	−Lack of environmental responsibility of stakeholders	Cantú et al., 2021; De Jesus & Mendonça, 2018; Dhir, Koshta, et al., 2021; Dhir, Sadiq, et al., 2021; Donner et al., 2021; Ferronato et al., 2019; Guldmann & Huulgaard, 2020; Hobson, 2020; Kirchherr et al., 2017, 2018; Paletta et al., 2019; Singh & Giacosa, 2019
External factor—resources available to the company	+ Business, technological and economic interactions	Babri et al., 2018; Chembessi et al., 2022; Laskurain-Iturbe et al., 2021; Ormazabal et al., 2018; Urbinati et al., 2021; Uriarte-Gallastegi et al., 2022; Vallecha & Bhola, 2019
	+ The implementation of CE activities driven by suppliers	Alhola et al., 2019; Braulio-Gonzalo & Bovea, 2020
	+ Available public resources: physical infrastructure, utilities, buildings, or roads	De Jesus & Mendonça, 2018; Pagano et al., 2018; Russell et al., 2020
	−Lack of available public resources: physical infrastructure, utilities, buildings, or roads	Cantú et al., 2021; Guldmann & Huulgaard, 2020
	−Supply chain barriers such as lack of transparency or trust between actors	Cantú et al., 2021; Despeisse et al., 2017; Fonseca et al., 2018; Guldmann & Huulgaard, 2020; Gupta et al., 2019; Landeta Manzano et al., 2015; Landeta-Manzano et al., 2017; Linder & Williander, 2017; Mishra et al., 2021; Vermunt et al., 2019; Yu et al., 2021

Note: + Drivers, − Barrier.
Source: Prepared by the authors.

The main groups in relation to the actions carried out by companies on their way to the CE are structured in Table 3. These groups have been classified according to the area of the norm to which they most clearly affect, to which a first general group has been added.

The actions collected are very varied. The most highlighted researches study the development of certified management system (Daddi et al., 2019; Fonseca et al., 2018; Fonseca & Domingues, 2018; Fortunati et al., 2020; Heras-Saizarbitoria et al., 2011; Ronalter et al., 2022), the new requirements in the supply chain (Daddi et al., 2019; Fonseca et al., 2018; Fonseca & Domingues, 2018; Fortunati et al., 2020; Heras-Saizarbitoria et al., 2011; Ronalter et al., 2022), the attempt to involve the customer in the eco-design of new products (Bocken et al., 2016; De los Rios & Charnley, 2017; den Hollander et al., 2017; Dey et al., 2022; Franco, 2019), the importance of industrial symbiosis processes in the transition to CE (Donner & Radić, 2021; Eikelenboom & de Jong, 2022; Konietzko et al., 2020; Witjes & Lozano, 2016), the development of product-service system (de Jesus Pacheco et al., 2019; Lieder & Rashid, 2016; Michelini et al., 2017; Rosa et al., 2019), the importance of public institutions and the companies working for them in promoting responsible consumption (Bernon et al., 2018; Dey et al., 2022; Guarnieri et al., 2020; Tseng et al., 2020; Tunn et al., 2019), the importance of preventive and predictive maintenance in life extension (Arana-Landín et al., 2020) and the importance of waste management to reduce waste to landfill and increase reuse (Fortunati et al., 2020; Ghisellini et al., 2016; Potting et al., 2017).

To conclude the analysis of the literature, Table 4 systematises the main results obtained. In this case, they have been classified into the three dimensions of sustainable development, plus a first general section for cases where the effects are significant in several dimensions. In the literature, there is no agreement on the effects of managing the CE economy on economic performance. While some authors link it with an improvement of these outcomes (Caputo, 2021; Gangi et al., 2019; Kazancoglu et al., 2018; Kucharska, 2020; Lüdeke-Freund et al., 2019; Mazzucchelli et al., 2022; Rosa et al., 2019; Syed Alwi et al., 2017; Tkalac Verčič & Sinčić Ćorić, 2018; Yildiz Çankaya & Sezen, 2019), others do not confirm it (Demirel & Danisman, 2019; Katz-Gerro & Lopez Sintas, 2019; Türkeli et al., 2018). However, the

TABLE 3 Main actions developed by companies to move towards CE management.

Area	Description	References
General	Sustainable development business strategies and actions related to human resource management	Marrucci et al., 2022; Subramanian & Suresh, 2022
	Analysis of different CE activities and their impact on sustainable development	Dey et al., 2022; Landeta-Manzano et al., 2017
	Obtaining environmental certifications (e.g., ISO 14000, OHSAS 18001 or FSC (Forest Stewardship Council) to improve environmental performance and to start CE management systems	Daddi et al., 2019; Fonseca et al., 2018; Fonseca & Domingues, 2018; Fortunati et al., 2020; Heras-Saizarbitoria et al., 2011; Ronalter et al., 2022
	CE activities are mainly related to Sustainable Supply Ecodesign, Responsible Consumption or Efficient Management of materials or products at the end of their life	Blomsma & Brennan, 2017; Kirchherr et al., 2017
	Biodiversity and environment's preservation actions such as commitment to reduce CO_2 emissions, waste, water consumption, and/or plastic	Fan et al., 2019; Farooque et al., 2019; Rogetzer et al., 2019
	The likelihood of adopting a CE activity depends on the experience gained from previous implementation of other CE activities as well as on the industrial sector in which the company operates	Katz-Gerro & Lopez Sintas, 2019
Sustainable supply	Activities like using environmental and social criteria in the selection of suppliers, local sourcing to mitigate risks, supply chain collaboration, use of renewable energy	Dey et al., 2022; Ghisellini et al., 2016; Potting et al., 2017
	Increase the use of natural or organic raw materials by 80% to 100%	Cinelli et al., 2019; Fortunati et al., 2020; Landeta-Manzano et al., 2017
Ecodesign	Product and process design to enable different CE activities to be undertaken	Barón et al., 2020; Bocken et al., 2016; De los Rios & Charnley, 2017; Fortunati et al., 2020; Linder & Williander, 2017; Stewart & Niero, 2018
	Redesigning the supply chain for both end-of-life product recovery and efficient utilisation of by-products	Hussain & Malik, 2020
	Product design in collaboration with SME customers	Bocken et al., 2016; De los Rios & Charnley, 2017; Den Hollander et al., 2017; Dey et al., 2022; Franco, 2019
	Lack of consumer involvement and acceptance, although the authors agree that consumer participation is essential	Hazen et al., 2017; Jones & Comfort, 2017; Kirchherr et al., 2017; Young et al., 2018
	Use of biodegradable materials	De Römph & Van Calster, 2018; Simon, 2019
	Adoption of the Environmental Management standard ISO 14006 following the guidelines for incorporating ecodesign	Arana-Landin et al., 2012; Arana-Landin & Heras-Saizarbitoria, 2011; Landeta-Manzano et al., 2017
Industrial symbiosis	Importance of this action area for the transition to an EC	Donner & Radić, 2021; Eikelenboom & de Jong, 2022; Konietzko et al., 2020; Witjes & Lozano, 2016
	Business initiatives that focus on by-product valorisation and require partnerships with other organisations	Donner et al., 2021
	Business partnerships to facilitate the reprocessing system or circulate goods	Stewart & Niero, 2018
	Collaboration with different companies in the supply chain to promote waste management, which become inputs in the supply chains of CEBM	Vermunt et al., 2019
	Forming a collaborative environment throughout the supply chain	Dey et al., 2019; Dey, Malesios, De, Budhwar, et al., 2020; Kristensen & Mosgaard, 2020; Saidani et al., 2019
Functional economy	Product-service system development	De Jesus Pacheco et al., 2019; Lieder & Rashid, 2016; Michelini et al., 2017; Rosa et al., 2019
	Circular business models that mainly establish recovery systems for reuse, for repair and, to a lesser extent, extending the value of the product through rental services	Stewart & Niero, 2018
Responsible consumption	Policy makers and SME self-motivation are the main drivers of practices in this action area	Bernon et al., 2018; Dey et al., 2022; Guarnieri et al., 2020; Tseng et al., 2020; Tunn et al., 2019

TABLE 3 (Continued)

Area	Description	References
	Biodiversity and environment's preservation actions such as commitment to reduce CO_2 emissions, waste, water and/or plastic consumption	Rogetzer et al., 2019
	Support recycling and resource recovery infrastructures through recycling campaigns, supplier initiatives or by encouraging the use of recycled content or renewable materials	Stewart & Niero, 2018
	Alternative ways to optimise transports such as car sharing. Promotion of responsible use of products, recycling, and reuse	Fortunati et al., 2020
Life extension	Reusable containers and packaging	Fortunati et al., 2020
	Analyse the impact of maintenance activities on life extension and environmental impact	Arana-Landín et al., 2020
End of their useful life	Actions related with waste management	Ghisellini et al., 2016; Potting et al., 2017
	Reduce landfill waste by replacing disposable plastic packaging with packaging made from recycled materials	Fortunati et al., 2020
	Use of new smart technologies to promote efficient waste management	Dantas et al., 2021

Source: Prepared by the authors.

positive effect it has on environmental outcomes is shared unanimously (Bertoni, 2017; Burke et al., 2021; De los Rios & Charnley, 2017; Dey et al., 2019, 2022; Dey, Malesios, De, Chowdhury, & Abdelaziz, 2020; Franco, 2017; Jawahir & Bradley, 2016; Kane et al., 2018; Landeta Manzano et al., 2015; Lieder & Rashid, 2016; Lindström, 2016; Liu et al., 2018; Malesios et al., 2018, 2020; Manninen et al., 2018; Masi et al., 2017; Nasir et al., 2017; Panda et al., 2017; Romero & Rossi, 2017; Suchek et al., 2021; Tecchio et al., 2017; Tseng et al., 2016; Zhu et al., 2007). Some authors link these effects to improved supply chain collaboration, lean practices, energy efficiency measures, and increased reuse (Kumar et al., 2019; Malesios et al., 2018, 2020), while others link them to better management (Fonseca et al., 2018; Lucianetti et al., 2018). With respect to social outcomes, although some authors do not confirm their positive effects (Katz-Gerro & Lopez Sintas, 2019; Türkeli et al., 2018), others highlight benefits for different stakeholders; employees (Atiku, 2020; Gui et al., 2022; Lei et al., 2021; Schroeder et al., 2019), customers (Rosa et al., 2019; Sassanelli et al., 2018), and the regional economy (Rosa et al., 2019).

4 | METHODOLOGY

First, considering that the diffusion of the XP X30-901 standard is at a very early stage, a qualitative case study methodology was used, following the methodological recommendations of Yin (2018), as can be seen in Figure 2. The use of qualitative methods allows to considerably increase the knowledge of the behaviour of organisations and, among all of them, the case study makes it possible to generate a very high level of realism in the conclusions of the research (Villarreal Larrinaga & Landeta Rodríguez, 2010). It makes it possible to analyse the phenomenon in its real context, considering all aspects of the problem, and using multiple sources of quantitative and/or qualitative evidence simultaneously (Eisenhardt, 1989). Some authors define it as one of the most appropriate for the study of business organisations (Eisenhardt, 1989; Villarreal Larrinaga & Landeta Rodríguez, 2010; Yin, 2018). Another element to bear in mind is that quantitative methods discard exceptional, unlikely or infrequent behaviours, which are precisely the basis of competitive advantage (Villarreal Larrinaga & Landeta Rodríguez, 2010). Moreover, the case study makes it possible to start an investigation without knowing the precise limits of the case, and some of the conditions initially considered as contextual may even end up being part of it (Yin, 2018).

Second, an Italian company was selected. We will give the fictitious name of circular economy water treatment (CEWT), being a pioneer company in CE practices. This company is one of the first five companies to be certified according to XP X30-901 and, in addition, it has an extensive previous experience in CE.

Thirdly, once the literature review had been conducted, the methodology and the case had been selected, and the unit of analysis was defined.

Fourth, preliminary interviews were conducted with five consultants and three auditors who had experience in the process of adopting and certifying other standards related to the CE, such as ISO 14006 or ISO 50001.

Fifth, these preliminary tasks allowed us to design a case study protocol based on Yin's (2018) guidelines, including the generic purpose of the case study; the field procedure (quantitative and qualitative sources of information, methods of evidence collection, key informants…); study questions; and the case study report guideline. It was intended to avoid undue limitation of the results, while ensuring internal consistency, reliability of the research and in-depth investigation of some specific aspects (Maxwell & Miller, 2008).

Sixth, the research work was divided into four main phases. The case study was conducted between March and June 2022.

TABLE 4 Main CE results obtained by companies.

Dimension	Description	References
General	Adopting the CE model allows for more sustainable results	Crecente et al., 2021; Dey, Malesios, De, Budhwar, et al., 2020; Dey, Malesios, De, Chowdhury, & Abdelaziz, 2020; Geissdoerfer et al., 2020; Kristensen & Mosgaard, 2020; Zhu et al., 2019; Zucchella & Urban, 2019
	Adopting CE model does not assure economic and social performances	Katz-Gerro & Lopez Sintas, 2019; Türkeli et al., 2018
	Taxonomy of CE indicators	Kristensen & Mosgaard, 2020
Economic	Improved corporate reputation, leading to higher financial performance, especially in terms of profitability, market share, revenue and return on investment	Caputo, 2021; Gangi et al., 2019; Y. Kazancoglu et al., 2018; Kucharska, 2020; Lüdeke-Freund et al., 2019; Mazzucchelli et al., 2022; Rosa et al., 2019; Syed Alwi et al., 2017; Tkalac Verčič & Sinčić Ćorić, 2018; Yildiz Çankaya & Sezen, 2019
	The adoption of practices related to the CE's fields of action does not guarantee positive economic results	Demirel & Danisman, 2019
	The implementation of practices related to CE contributes to the economic performance	Agan et al., 2013; Bertoni, 2017; Cesar da Silva et al., 2021; Cheffi et al., 2021; Dey, Malesios, De, Budhwar, et al., 2020; Dey et al., 2022; Franco, 2017; Gusmerotti et al., 2019; Jawahir & Bradley, 2016; Kane et al., 2018; Kumar et al., 2019; Landeta Manzano et al., 2015; Lee, 2008; Lieder & Rashid, 2016; Lin et al., 2019; Lindström, 2016; Lucianetti et al., 2018; Masi et al., 2017; Moric et al., 2020; Ormazabal et al., 2018; Ramos et al., 2022; Romero & Rossi, 2017; Schischke et al., 2016
Environment	The implementation of practices related to the CE practices helps to achieve higher environmental performance.	Bertoni, 2017; Burke et al., 2021; De los Rios & Charnley, 2017; Dey et al., 2019, 2022; Dey, Malesios, De, Chowdhury, & Abdelaziz, 2020; Franco, 2017; Jawahir & Bradley, 2016; Kane et al., 2018; Landeta Manzano et al., 2015; Lieder & Rashid, 2016; Lindström, 2016; Liu et al., 2018; Malesios et al., 2018, 2020; Manninen et al., 2018; Masi et al., 2017; Nasir et al., 2017; Panda et al., 2017; Romero & Rossi, 2017; Suchek et al., 2021; Tecchio et al., 2017; Tseng et al., 2016; Zhu et al., 2007
	Supply chain collaboration, lean practices, energy efficiency measures, reuse and recycling can pay off	Kumar et al., 2019
	Advanced management practices or the adoption of environmental management models improve environmental results	Fonseca et al., 2018; Lucianetti et al., 2018
Social	Human resource actions such as training for the wider adoption and dissemination of CE practices have a positive effect on companies' employees	Gui et al., 2022; Lei et al., 2021; Schroeder et al., 2019
	Knowledge management related to CE could increase employment opportunities	Atiku, 2020
	CE business models based on the Product-Service System (PSS) concept increase the involvement of final customers, who become co-producers in the value-creation process	Rosa et al., 2019; Sassanelli et al., 2018
	The cost of some environmental and social practices can hinder the achievement of social sustainability	Dey et al., 2019; Inman & Green, 2018
	The implementation of practices related to the CE contributes to social benefits	Bertoni, 2017; Jing & Jiang, 2013; Lindström, 2016; Masi et al., 2017; Rizos et al., 2015; Roos, 2014; Schaltegger et al., 2011; Schaltegger & Wagner, 2011; Veleva & Bodkin, 2018
	CE initiatives contribute to the local economy and social welfare	Blome et al., 2014; Cheffi et al., 2021; Testa et al., 2016

Source: Prepared by the authors.

1. The first phase was designed to try to delve into the main drivers and barriers to adopt and certify the company and, more specifically, among the external motivations, the importance of customer requirements, improving the company's image, increasing market share and participation in tenders, and among the internal motivations, a greater sensitivity to environmental issues were studied.

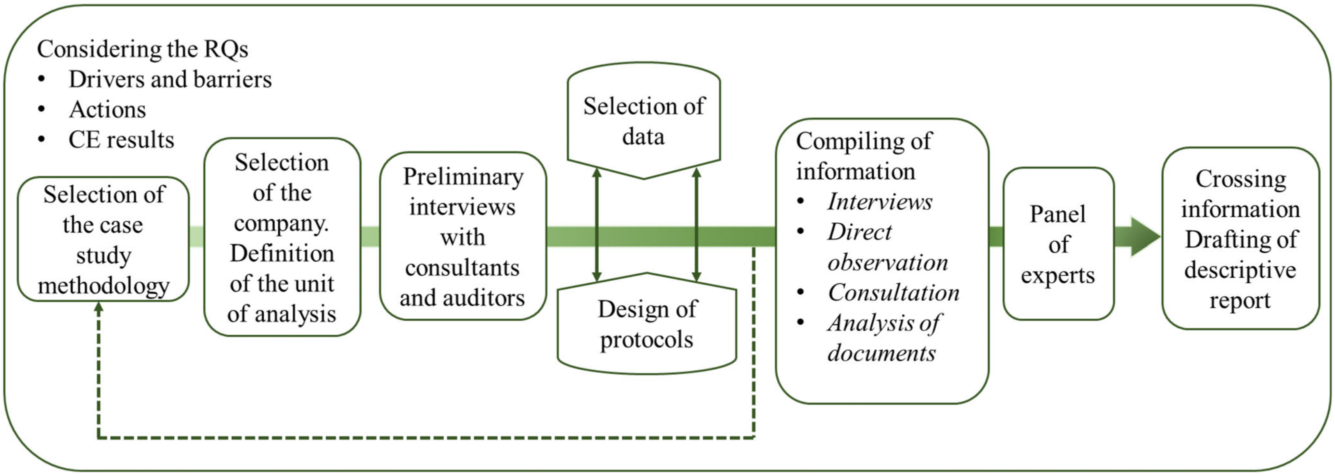

FIGURE 2 Research process carried out.

Direct information was gathered through in-depth interviews with a manager and a technician, and informal talks were held with seven technicians of the company to clarify specific issues in different stages of the research. The interviews were transcribed, and field notes added where appropriate. Email was used to clarify specific questions that were not sufficiently clear, and on more specific occasions, the MS Office 365 Teams collaboration platform was used. In addition, 20 of the company's internal and external documents were also gathered covering different areas related to the management of CE practices, from sustainable sourcing to materials or end-of-life product management. All the information obtained was recorded, classified and combined to create an evidence database (Miles et al., 2020). The enabling agents were analysed with the aim of examining the following aspects in more depth: Experience of working with other management standards, Advisory services, Audit board, Public administrations, Clients and suppliers.

2. In the second phase, the main actions carried out by the company were analysed according to the main areas of action of the CE. Unlike the previous phases, this phase was structured according to the areas indicated by the standard: Sustainable supply, Ecodesign, Industrial symbiosis, Functional economy, Responsible consumption and Extension of duration and Effective management of end-of-life materials or products.
3. In the third phase, we analyse the circularity results of the certification period from 2019 when adoption started until the certification year 2021. This analysis was developed based on objective indicators of material, energy, and water management, shown in Section 5.3, published after being audited in the company's sustainability reports.

Seventhly, to conclude the fieldwork, to reinforce the previous conclusions, it was decided to create a balanced panel of experts. Semi-structured in-depth interviews were conducted with experts from the fields of auditing, consultancy, and public administration, and the results of the previous phase were shown to them, see Table A1 in Appendix A. According to Patton (2014), this is one of the possible techniques for the constructive validity of qualitative research. The author points out that it is necessary to have experts from different disciplines, but it is also possible to have experts from the same area of knowledge, but from different fields. In any case, the experts should bring different perspectives. Therefore, if each expert or evaluator interprets the information provided in the same way, then it is possible to speak of constructive validity. Moreover, as (Thurmond, 2001) points out, triangulation allows researchers to deepen their understanding of the issues and maximise their confidence in the results of qualitative studies. With this last work, the empirical work was completed, and the conclusions of the research were drawn up.

5 | EMPIRICAL STUDY

CEWT is a large limited liability company located in northern Italy that manages integrated water services. In 2021, it had a turnover of 240,721,687 euros and a performance of 1.14%. The sum of raw material costs (13,769,673 euros), construction materials (7,540,386 euros), and consumables (5,045,453 euros) does not reach 11% of its turnover. Its energy consumption is high in comparison with other companies in the sector, 852,369,704 MJ, but it is committed to consuming energy from renewable sources (93.9% of its consumption) and developing projects to increase its energy production, which has reached 46,965,294 MJ. This production has been obtained, mainly, with heat from thermo-valorisation processes. Specifically, in its waste management, it is worth noting that of the 105,604 tonnes of waste produced, in addition to recovering 56% of this, 26% is used in thermo-valorisation processes, and of the 70,781 tonnes of sludge, 39.1%. Finally, it should be noted that 52.8% of the sludge is used for the production of phosphorus-rich bio-fertilisers. These results have been obtained thanks to its involvement in CE. Specifically, in the previous year 2020, the company invested 34 million euros in the development of projects in this area.

Although the adoption process began at the end of 2019, it already had some years of experience developing actions to improve its circularity. The company has certified its CEPMS according to the XP X30-901 standard in the first part of 2021 by a company with extensive experience in the certification of Management Systems according to the ISO 14001 or ISO 9001 standard. In this case, we checked that the ISO 9001 or ISO14001 certificates collect the accreditation of this company to issue these certifications but in the XP X30 901 certificate, the register has not been attached.

5.1 | Main drivers and barriers for companies to move towards CE through XP X30-901

The external motivations identified have been predominant in starting the process of adoption and certification. Prior to taking this decision, the company carried out a risk analysis, following the recommendations of the Task Force on Climate-Related Financial Disclosures and considering the probability and severity of the risks related to climate change. This procedure has identified the potential risks that CEWT experiences or generates through its activities and along the value chain, serving as a starting point for planning actions to address them.

As shown in Figure 3, by assessing the impact and probability of occurrence, this analysis allowed them to classify the risks into four categories that quantify the risk from highest to lowest according to the colours red (highest risk index), orange, yellow, and green (lowest risk index).

Because of this analysis, in relation to climate change, the two main risks detected were those related to the market and to extreme situations related to major storms.

The market risk is precisely the main motivation that encouraged the company to start the process of adopting and certifying the CE standard. The managers agree on its value in strengthening their market share with a more CE-oriented approach. They point out that this certification allows them to have better positioning, mainly to work with the public administration. In line with this comment, it was found that the top five companies certified by AFNOR obtain a very high proportion of their revenues through contracts with the public administration. In addition, but to a lesser extent, they emphasise that environmental sensitivity in the company has played an important role in adopting this management system.

When assessing the process of implementing the CEPMS, the enabling agents consider that, in their role, their experience in working with management systems, has not only been the main driver, but has also contributed significantly to boosting circularity outcomes. They are currently working with an integrated management system based on the following standards:

1. UNI EN ISO 9001 'Quality Management Systems'.
2. UNI EN ISO 14001 'Environmental management systems'.
3. UNI EN ISO 45001 'Occupational health and safety management systems'.
4. UNI EN ISO 22000 'Food, household and road tanker safety management systems'.
5. UNI CEI EN ISO 50001 'Energy management systems'.
6. SA 8000 'Corporate Social Responsibility'.
7. UNI ISO 37001 'Management systems for the prevention of corruption'.
8. AFNOR XP X30-901:2018—'Circular economy—Management system for circular economy projects—Requirements and guidelines'.

Although the company has a clear commitment to have a fully integrated management system, the acquisition of companies and the opening of new business lines has limited their level of integration. Specifically, the systems corresponding to the UNI EN ISO 14064-1 'Greenhouse Gas Declaration' and to the Italian UNI for the 'Sustainability of Biofuels and Bioliquids 14/11/2019 for the

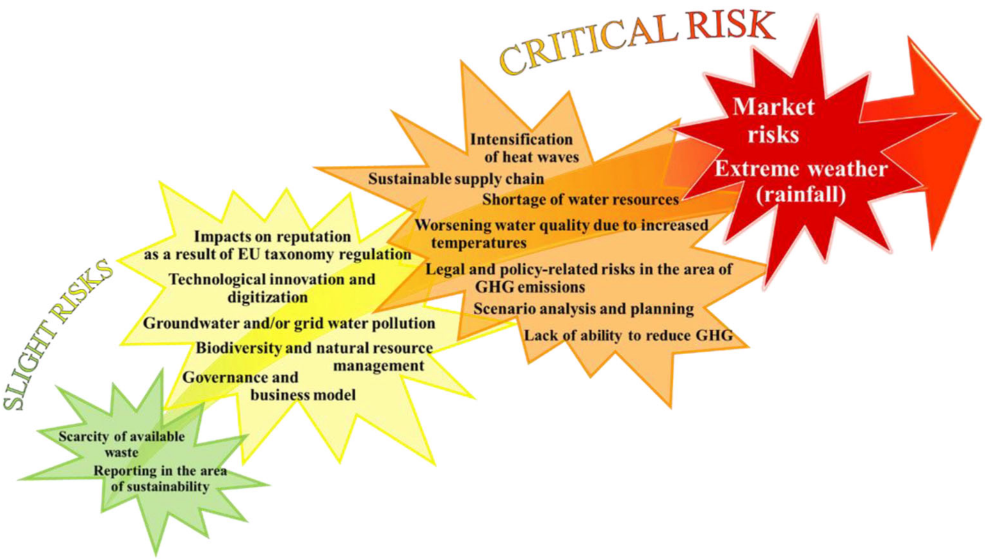

FIGURE 3 Risk analysis of CEWT.

sustainability of the production of Biomethane from sludge purification' are certificated but not integrated. The managers consider that both certificates are closely related to the CE and many of the actions fulfil the requirements of the standard XP X30 901 have been adapted from previous projects. Finally, the managers highlight that they have three laboratories accredited according to the UNI CEI EN ISO/IEC 17025 standard for the management of drinking water and sewage water. In this regard, they emphasise their importance for the evaluation phase in the PDCA cycle required by the management system.

Although to a lesser extent, the managers consider other enabling agents important to complement their internal experience. Specifically, they rate the involvement of customers and suppliers positively. With them, the company managed to increase the circularity of materials, energy, and water through joint projects. For example, with the collaboration of suppliers, they have developed projects for the generation of bioenergy and treated water. In addition to being self-consumed, treated water is sold to several transport and cleaning companies in the area. This project has allowed them to improve circularity reducing the waste generated and the need for external energy. In addition, they positively rate the support they have received from auditors, consultants, and public administrations, not only in the process of adopting this standard but also in that of their integrated system. In this sense, they highlight the participation of the public administration in circularity projects. These latter enabling agents were also identified in Nyvall et al. (2022).

5.2 | Main actions developed by companies to move towards CE by adopting XP X30-901

Once the initial situation had been analysed, the company designed an action plan to integrate the requirements of the standard into the integrated management system. Before, an analysis was made of the requirements that were previously fulfilled, the requirements that had been worked on but were not fulfilled and/or had not been documented, and those that were not fulfilled and needed to be worked on from earlier stages. Subsequently, taking into account the company's strategic planning, the action plan was generated taking the structure of the standard as a reference. In order to develop this plan, groups of projects were generated and managed autonomously, although those responsible for the management system made sure that each of the requirements of the standard were fulfilled.

As a result, the large number of actions that have been developed in the process of implementing the CEPMS is noteworthy. These actions have been classified according to the XP X30 901 standard's seven areas of action, although, as can be seen in Figure 4, many of them affect several areas.

5.2.1 | Sustainable supply

Actions have been developed to improve the efficiency of non-circular materials, water, and energy consumption. An important effort is required of the company's suppliers who are assessed based on

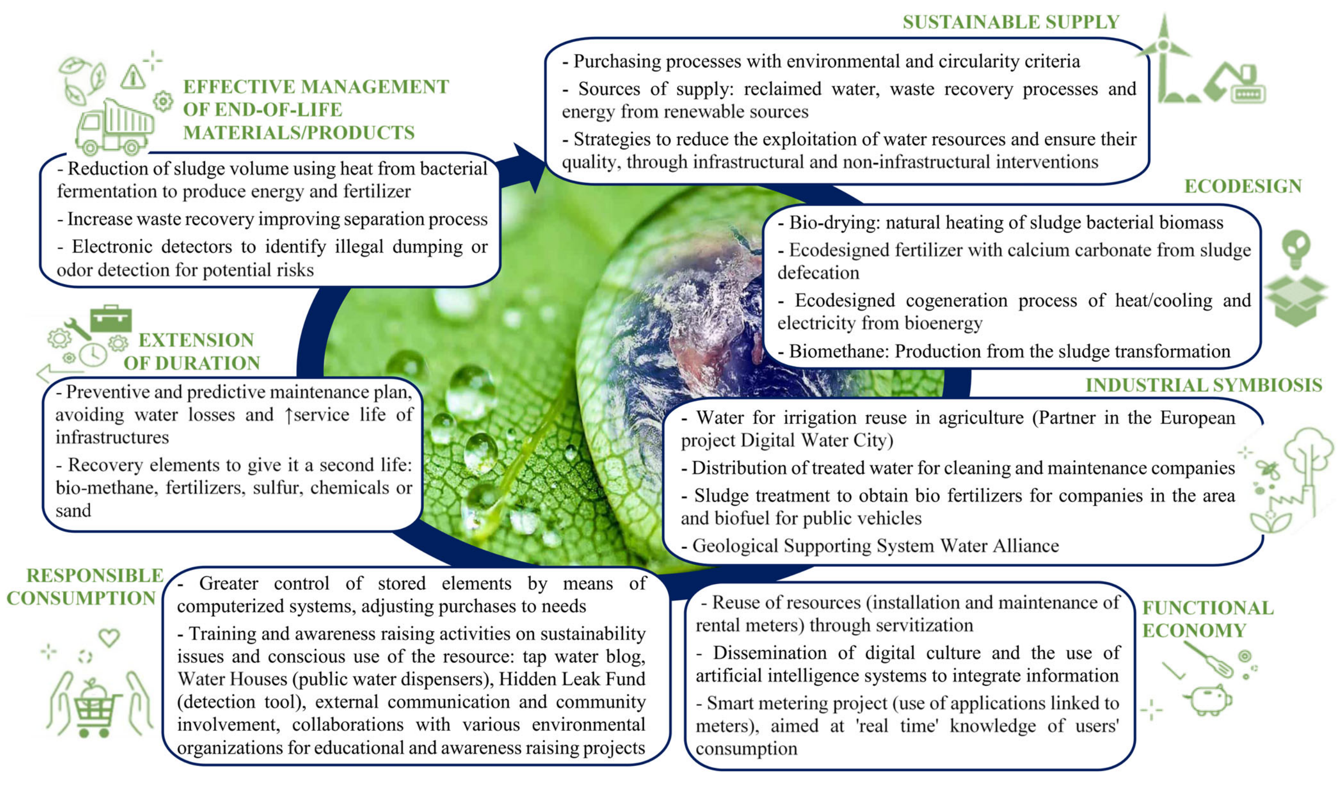

FIGURE 4 Main actions in each area developed to adopt the standard XP X30-901.

environmental criteria. In this way, in relation to materials, circularity criteria have been integrated into purchasing procedures. Processes have been developed to recover waste such as volatile fatty acids, which are used as a substitute product in discontinuous sequencing reactors to eliminate nitrogen and phosphorous. Likewise, processes are designed to take advantage of the sand extracted from the purification process as raw material in the company's works. In relation to energy, its own biomethane production is established. This self-consumption had the aim to gradually reduce its demand for external energy.

5.2.2 | Ecodesign

Several in-house eco-design projects have been launched to generate efficient processes, energy, and products. For example, the bio-drying process has been eco-designed by assessing the natural heating caused by the bacterial biomass present in the sludge. In addition, biofuels and eco-friendly fertilisers have been produced from sewage sludge. Specifically, the manufacture of fertilisers takes advantage of the calcium carbonate obtained.

5.2.3 | Industrial symbiosis

The company's role in industrial symbiosis projects has been linked to the production of bioenergy from waste, the reuse of treated water, and the use and production of bio fertilisers. Treated water has begun to be distributed to the companies in charge of the cleaning and maintenance of the municipalities in the region and farm firms. In another important project, the treatment of sludge from water purification is used to produce thermal energy and bio fertilisers that are distributed to companies in the region. Finally, the production of bioenergy is being continuously improved. Of relevance is the project to take advantage of the anaerobic bio digesters present in the wastewater treatment plants to turn organic waste into clean bio methane energy for vehicles of companies in the area and public transport in the region.

5.2.4 | Functional economy or servitisation

The basic function of the company is to offer services or products for direct consumption. For this reason, this section is not considered as critical as others are. However, measures have been taken whereby the company promotes services such as the installation and maintenance of rental meters among its customers. In addition, customers are provided with applications linked to the meters that allow them to have greater control over the management of water and energy consumption.

5.2.5 | Responsible consumption

Greater control of stored items has been introduced through computerised systems, allowing purchases to be adjusted to needs. Furthermore, the company carries out important awareness-raising work through the tap water blog, the Water Houses and the Hidden Leak Fund.

5.2.6 | Extending the duration of use

Various projects have been developed to increase the interconnection of the channels. These projects make it possible to better manage water consumption and facilitate maintenance. In maintenance management, a preventive and predictive maintenance plan has been prepared to avoid water losses and extend the useful life of the infrastructures. With respect to this point, analysis has begun on the causes of actual losses by replacing and modernising the meters installed to resolve metering errors. In addition, part of the recovered water is used in their works, thus reducing external consumption. On the other hand, in advanced bio refineries, this monitoring makes it possible to give a second life to secondary raw materials, obtaining bio methane, fertilisers, sulphur, various chemical products and sand.

5.2.7 | Efficient management of materials or products at the end of their useful life

This is considered one of the most relevant areas of action. In fact, the Sustainability Plan aims to reduce the volume of non-circulated waste produced. Globally, there is a plan to reduce the waste sent to landfill. To achieve this continuous reduction, actions are being introduced to improve waste separation. The recovery of sulphur by adjusting the doses of desulphurization reagents, of bioplastics from sludge treatment and of food waste used to produce biogas and fertilisers are the most important actions. In addition, the sludge section has had its volume reduced by means of the heat produced by the fermentation of the bacteria. Another noteworthy aspect in this section has been the investment in new technologies. The electronic detectors help to reduce potential risk identifying illegal dumping and the odour detection systems. At a global level, all these actions have had an important effect on emissions.

5.3 | Main CE results achieved by companies by adopting XP X30-901

5.3.1 | General results

As the scope of the CE actions affects the entire business group, we will present the overall CE results comparing the design period and start of establishment 2019, the year of establishment 2020, and the first year of work with the CEPMS. The company's results are stable in terms of turnover and energy consumption, but there has been an increase in the amount of water treated and waste generated.

The variation in consumption that the company has had in relation to its sales can be seen in Table 5. The total cost of raw materials has been reduced by around 10% in relation to sales revenues. This reduction is mainly explained by reductions in material consumption for use in construction (16.5%). The disappearance of wholesale purchases of water in 2021 is also noteworthy.

Regarding the energy results, Table 6 shows that consumption remains stable. The percentage of this consumption coming from renewable sources experiences a slight increase. In addition, the energy produced by the company itself, mainly bio methane obtained in the wastewater treatment plants, shows an increase of more than 76% and reaches 5.51% of the energy consumed in 2021.

Regarding water management, in Figure 5 we can observe how the company has reduced water losses by 6.36% in 2021 compared to 2019. In addition, it has managed to increase the percentage of treated water by 10.15%, allowing reused water to be increased by almost 18% at the global level.

As it can be seen in Table 7, waste generated increased by almost 10% in 2021 compared to 2019. Despite this, there was an 11% decrease in waste disposed of, mainly due to a 33% increase in the use of waste in thermo-valorisation processes and an 8% increase in recovered waste. Similarly, sludge has increased by 15.5%. However, sludge management has improved, and the amount of sludge sent to landfill has decreased by more than 58%, due to a 21% increase in sludge for agriculture, a 36% increase in sludge for thermo-valorisation and a nearly 4% increase in sludge for cement production.

At the economic level, operating revenues have decreased by 1.23% between 2019 and 2021. However, the measures taken have contributed to improving process efficiency, which has enabled them to reduce costs by around 10%. The company's manager highlights the influence that the adoption of the standard has had on these savings. It has helped them to become aware of the need to establish improvement actions. Specifically, as the cause of these improvements, the director highlights the following in order of importance:

1. Optimal reorganisation of the treatment plant.
2. Improved control of materials and warehousing, allowing purchases and consumption to be adapted to needs.
3. The maintenance plan extends the useful life of the resources used.
4. The use of some elements, which were considered waste, as raw materials or to generate other lines of business.

In addition to these results, the company has analysed its economic activities based on EU Regulation 2020/852 establishing the European Taxonomy. CEWT published within the non-financial information for 2021 that 87.78% of the company's revenues, 85.28% of its capital expenditure, and 93.23% of its operating expenditure arise from the development of environmentally sustainable economic activities (activities that comply with the taxonomy).

5.3.2 | Main effects of the CE application on the three dimensions of sustainability

As highlighted by the company itself, in general, the results of adopting a CEPMS affect all three dimensions of sustainability (environmental, economic, and social), although in some cases one of them predominates. Considering this point of view, the results, presented in Figure 6, have been classified into four groups. The group shaded in blue includes the results that generally affect the three dimensions

TABLE 5 Raw material consumption in 2019, 2020 and 2021 in euros.

	2019	2020	2021	Var. 2019–2021	2019	2020	2021	Var. 2019–2021
Revenues x sales	243,722,886	236,650,408	240,721,687	−1.23%	100%	100%	100%	0.00%
Cost of raw materials	15,477,915	10,651,430	13,769,673	−11.04%	6.35%	4.50%	5.72%	−9.93%
Materials of construction	9,140,082	6,302,477	7,540,386	−17.50%	3.75%	2.66%	3.13%	−16.47%
Consumables	4,891,560	4,292,576	5,045,453	3.15%	2.01%	1.81%	2.10%	4.43%
Water purchases	225,901	187,071	-	−100%	0.09%	0.08%	0.00%	−100%

Source: Own elaboration based on information provided by CEWT.

TABLE 6 Energy management results in 2019, 2020 and 2021 in MJ.

	2019	2020	2021	Var. 2019–2021	2019	2020	2021	Var. 2019–2021
Energy consumed	852,453,576	863,027,855	852,369,704	−0.01%	100.00%	100.00%	100.00%	0.00%
En. cons. renew. sources	795,843,292	811,216,178	800,906,845	0.64%	93.36%	94.00%	93.96%	0.65%
Energy produced	26,935,008	43,434,896	46,965,294	74.37%	3.16%	5.03%	5.51%	74.38%
En. prod. photovol plants	1,037,658	879,181	1,213,369	16.93%	0.12%	0.10%	0.14%	16.94%
En. prod. treatment plants	25,897,350	42,555,715	45,751,925	76.67%	3.04%	4.93%	5.37%	76.68%

Source: Own elaboration based on information provided by CEWT.

and the other three groups present results according to the dimension of main impact: environmental (shaded in green), economic (shaded in yellow), and social (shaded in red).

These results have also been sorted into the seven areas of action. As with the actions, the results of the actions may affect more than one area, so that in some cases the same result is referred to from different perspectives.

In general, the actions developed have achieved positive results in all areas, among which the following can be highlighted.

Sustainable supply

The reduction of risks related to climate change with measures that increase infiltration and water storage capacity by 10% affects all three dimensions. In the environmental dimension, local sourcing continues to increase by 13%, the use of bio methane by 74% and the percentage of suppliers qualified with sustainability criteria reaches 49%. On an economic level, purchasing costs have been reduced by 11% as some waste, such as sludge or sand, has been given a second life. In addition, the purchase of water has been eliminated, reducing the company's supply costs by 25,901€.

Ecodesign

The ecodesign processes have enabled positive results to be obtained in all three dimensions. Mainly, they have been oriented towards processes for generating energy from waste. Specifically, the thermos-valorisation process has been redesigned, increasing the energy obtained by 17%, the production of biomethane from sludge has begun, and obtaining 648,529 m^3 and 11,120 Mw/h of energy has been obtained during the drying of sludge through the bacterial biomass fermentation process.

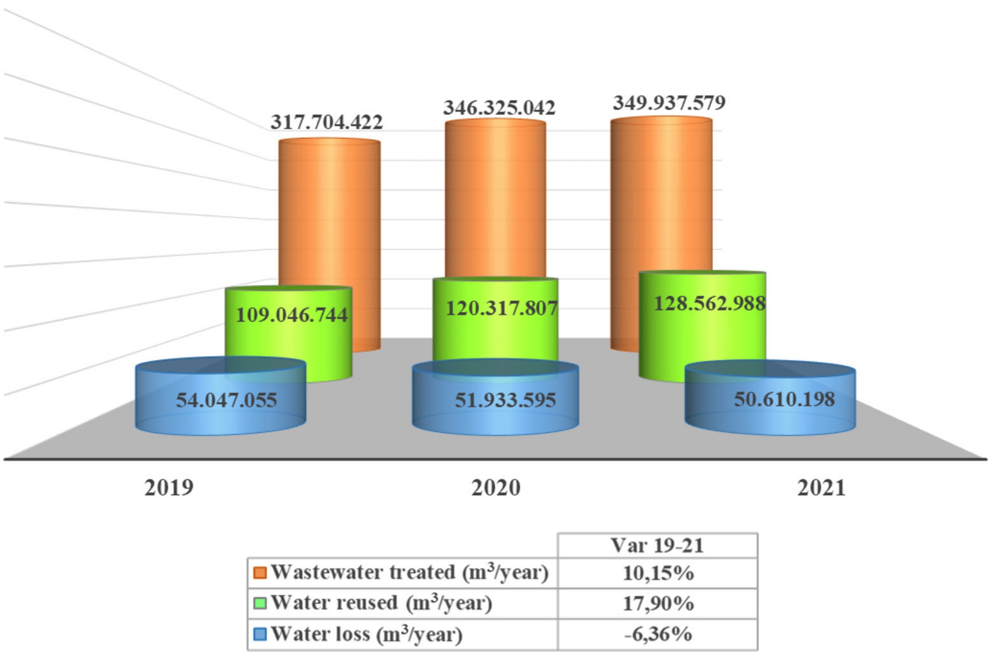

FIGURE 5 Water management results in 2019, 2020 and 2021.

TABLE 7 Waste and sludge management results in 2019, 2020 and 2021 in tons.

	2019	2020	2021	Var. 2019–2021	2019	2020	2021	Var. 2019–2021
Waste produced	96,310	96,003	105,604	9.65%	100%	100%	100%	0.00%
Waste disposed	21,303	20,534	18,960	−11.00%	22.12%	21.39%	17.95%	−18.83%
Waste for thermo-valorisation	20,620	22,474	27,432	33.03%	21.41%	23.41%	25.98%	21.33%
Waste produced and recovered	54,387	52,995	59,213	8.87%	56.47%	55.20%	56.07%	−0.71%
Sludge	61,283	59,099	70,781	15.50%	100%	100%	100%	0.00%
Sludge agriculture and treatments	30,838	30,117	37,431	21.38%	32.02%	31.37%	35.45%	10.70%
Sludge for thermo-valorisation	20,296	23,387	27,685	36.41%	21.07%	24.36%	26.22%	24.40%
Sludge for cement manufacture	2319	2123	2407	3.78%	2.41%	2.21%	2.28%	−5.35%
Sludge sent to landfills	7830	3472	3257	−58.40%	8.13%	3.62%	3.08%	−62.06%
Sludge recovered	53,453	55,627	67,523	26.32%	55.50%	57.94%	63.94%	15.21%

Source: Own elaboration based on information provided by CEWT.

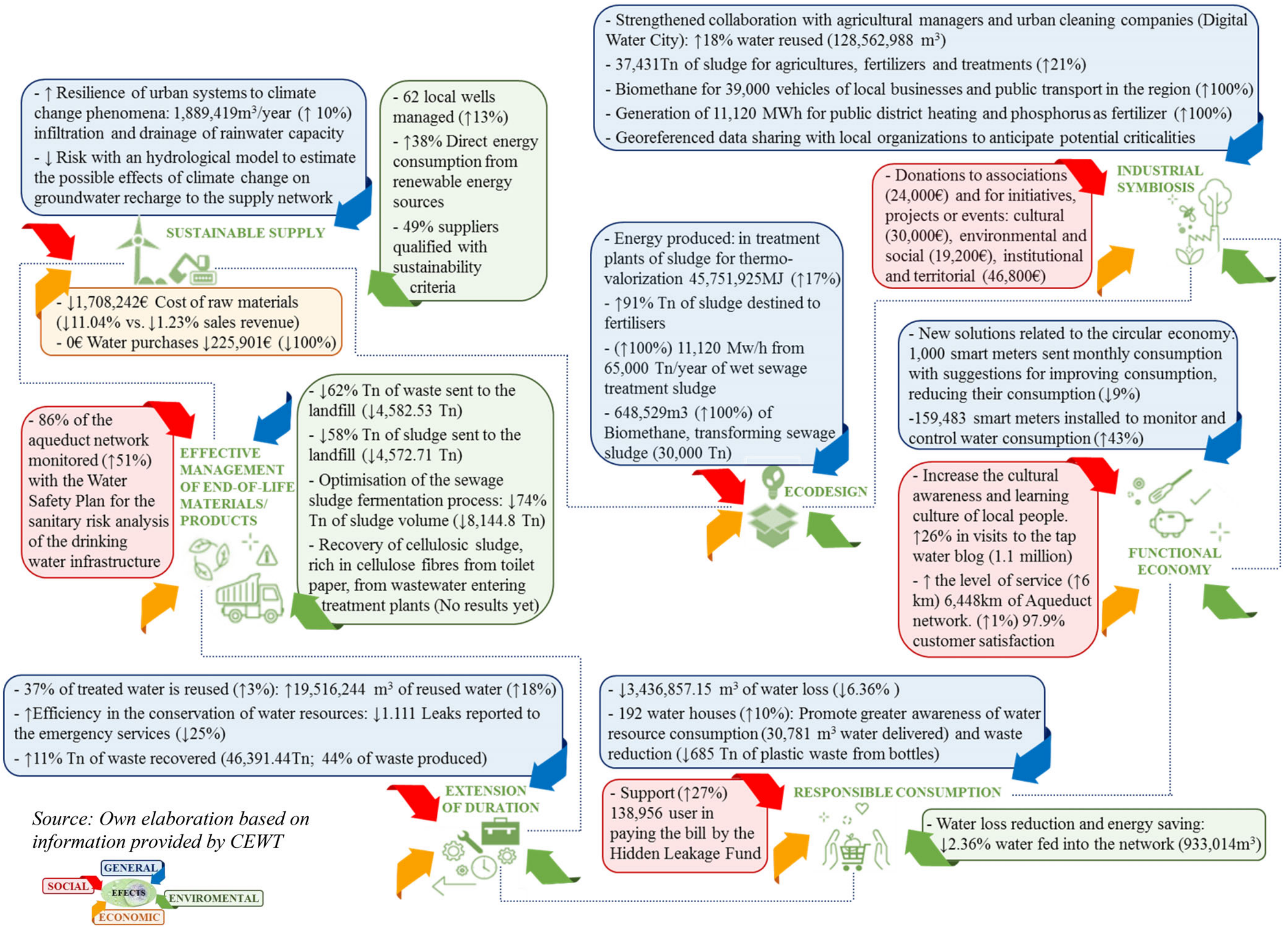

FIGURE 6 General social and economic effects. The group shaded in blue includes the results that generally affect the three-dimensions and the other three groups present results according to the dimension of main impact: environmental (shaded in green), economic (shaded in yellow) and social (shaded in red).

Industrial symbiosis

Within the symbiosis projects, it is worth highlighting the collaborations with agricultural groups for the reuse of water, which has increased its consumption by 18%, and the use of fertilisers obtained from sludge, which has increased by 21%. It is also worth highlighting the energy symbiosis projects with public institutions, supplying biomethane to 39,000 vehicles and providing 11,120 MW/h for heating public buildings.

Functional economy or servitisation

In this aspect, the company highlights the good social and environmental results obtained through communication with a Blog with more than 1,100,000 views to raise awareness of how to use water. Also noteworthy in this respect is the installation of 159,483 smart meters installed on a rental basis.

Responsible consumption

The reduction of water losses by 6.5% is significant. It has allowed them to achieve greater efficiency in water use. In addition, 192 water collection points have been set up, supplying 30,871 m^3 of water. It is estimated that through these actions a significant environmental improvement has been achieved by avoiding the generation of 685 tons of plastic waste.

Extending the duration of use

Improvements in the state of the infrastructures have allowed an 18% increase in water reused. In addition, it has been possible to recover 11 tons of waste (fertilisers, sulphur, various chemical products, and sand) which have been reused, obtaining environmental economic and social benefits.

Efficient management of materials or products at the end of their useful life

In this section, the reduction of 62% of waste and 58% in the case of sludge sent for incineration is noteworthy. The sludge drying process has also been improved, reducing its volume by 74%. They are waiting to quantify the environmental results of cellulose fiber collection, although the company itself is optimistic. At a global level, the actions taken have had an important effect on emissions.

Regarding the Sustainable Development Goals (SDGs), the company has increased its contribution in 2021. Given its activities, its largest contribution is focused on SDG 6—Clean Water and Sanitation (Support for the most needy users—1.3 million euros for social water subsidies and supplementary facilities for users and communities, 99.60% compliance drinking water, 98.01% compliance purified water, participation in Water Alliance and 8.5 million inhabitants served). In addition, significant actions and contributions were also highlighted to Goals 7—Affordable and Clean Energy (94% Energy consumed from renewable sources), 8—Decent work and economic growth (7.75% Index of accident frequency), 9—Industry, Innovation, and Infrastructure (Investments of 66.5 EUR/inhabitant/year), 10—Reducing Inequality (50% women on boards of directors), 12—Responsible Consumption and Production (128,562,988 m3 reused wastewater, 206.41 L consumption per capita daily and 44% of waste produced recovered), 13—Climate Action (100% emissions offset) and 17—Partnerships to Achieve the Goal (11.5% of investments is shared value).

6 | DISCUSSION AND CONCLUSIONS

To achieve a more sustainable society, it is necessary to develop a transformation process in all areas including business management (Dey et al., 2022; Marrucci et al., 2022; Subramanian & Suresh, 2022). Specifically, it is necessary to adapt companies to the new context, integrating and prioritising environmental aspects, in addition to the economic and social ones (Crecente et al., 2021; Dey, Malesios, De, Budhwar, et al., 2020; Dey, Malesios, De, Chowdhury, & Abdelaziz, 2020; Geissdoerfer et al., 2017; Kristensen & Mosgaard, 2020). This paradigm shift requires companies to adapt their management models, and management standards could be used as a reference tool to guide and facilitate this change (Dey, Malesios, De, Chowdhury, & Abdelaziz, 2020; Zhu et al., 2010; Zucchella & Urban, 2019). This model, like other management standards developed by ISO, such as ISO 14001, is based on the continuous improvement cycle (Daddi et al., 2019; Fortunati et al., 2020). This allows companies to systematise their management, and to be more aware of the main risks and opportunities in terms of the circular economy when planning actions. In addition, the matrix allows systematising the whole process, planning, action, evaluation, and post-action. Moreover, they should help companies to adapt to the legislative changes that will significantly increase the level of requirements (Pacurariu et al., 2021).

However, although there are numerous international management standards that cover specific areas of the CE, and other more general standards that integrate some of its areas, there is no specific ISO international standard for the CE. In this context, AFNOR has called for the need to design and publish a specific international standard and, taking the French standard XP X30-901 as a reference, is currently leading the drafting process of the future ISO 50004 to define the terminology, principles, and guidelines for the application of the EC. This standard is the basis for the ISO59000 series (Poponi et al., 2022).

This paper contributes to the research by analysing the adoption of a CEPMS based on the reference standard XP X30 901 by a pioneer company and by identifying the aspects related to the drivers, barriers, adoption process, and results obtained. This experience is not only relevant for the companies that will adopt CEPMSs but also for those agents involved such as, among others, standardisation organisations, consulting companies, auditing companies, public administration and the rest of the agents that make up the company's operating environment.

In this sense and confirming previous studies, the value, given by the administration to the use of management models related to the CE and the environment, plays a fundamental role (Agyemang et al., 2019; Arranz et al., 2022; Chembessi et al., 2022; Del Mar Alonso-Almeida et al., 2021; Ilić & Nikolić, 2016; Jakhar et al., 2018; Malinauskaite et al., 2017; Mallory et al., 2020; Milios, 2018; Nudurupati et al., 2022; Oghazi & Mostaghel, 2018; Sousa-Zomer et al., 2018; Urbinati et al., 2021; Wrålsen et al., 2021). It acts as an important driving force on its large suppliers, which, in turn, generate a chain effect downstream (Arana-Landin et al., 2012; Bressanelli et al., 2021; Landeta-Manzano et al., 2017). In fact, the market of the 10 companies certified in the first phase is highly dependent on public tenders, and specifically, in our case study, maintaining market share has been considered the main motivation, see Table 8. This motivation, confirmed by the group of experts (see Table A2 in Appendix A), in accordance with those reported in other studies on motivations to adopt and certify to the ISO 14001 standard, EMAS or ISO 14006, where external motivations related to the market were highlighted. (Fonseca & Domingues, 2018; Heras-Saizarbitoria et al., 2011; Heras-Saizarbitoria et al., 2016; Landeta-Manzano et al., 2017).

In addition, new environmental legislation should play a key role in this pull effect. Specifically in Europe, the disclosure of non-financial information related to the European Taxonomy and the integration of the European product digital passport in the near future, in sectors considered the most polluting should boost and facilitate the adoption of CE management practices by companies. The need to comply with the legal requirement to incorporate environmental information along the entire supply chain and to provide greater transparency and the comparability of the environmental sustainability of economic activities should encourage sustainable projects and should limit the risk of greenwashing (Heras-Saizarbitoria et al., 2016). In addition, it should allow capital flows to be redirected towards projects and activities that contribute to European climate and environmental objectives.

The results of previous studies on the importance of having a developed management system to facilitate the adoption process and achieve CE objectives have been confirmed (Barón Dorado et al., 2022; Fonseca et al., 2022; Heras-Saizarbitoria et al., 2016). The adoption of the standard has been a key driver to carry out numerous eco-innovation projects and actions in the seven areas and three dimensions covered by the standard. Their integration into the management system as a mechanism for action to plan, do, control and act processes has been of great help in facilitating the management of the company to improve the circularity results. The facilitating role and

TABLE 8 Drivers and barriers for companies to move towards CE management in literature versus through XP X30-901 on CEWT.

Main factors	Literature review	Case study – CEWT
Business models	+ Business models based on digital tech.	+ Integrated business management model
	– Lack of model compatibility	– No perceived compatibility problems in adding elements
Economic and financial factors	+/– Operating costs	+ Better position in the market and less uncertainty climate change
	+/– Financial viability	+ New incomes for new markets and reduction of energy needs
	– Investments required	– Great investment required
	– Uncertainty profit of reused products	+/– No evidence
	– Investment returns	- Investment return uncertainty
	– Uncertainty about commercial transaction	+/– No evidence
Business policies, strategies and practices	+/– Environmental culture of the company	+ Previous strategy include environmental culture
	+ Previous Circular practices	+ Prev. practices linked with other models
	– Organisational and product design factors	– New business lines (ecodesign product & process)
Internal company resources	+/– Availability of material resources	– Availability of waste to be reused
	+/– Human resources trained	– Trained required (New processes & targets)
	+ Internal stakeholders sensitised	+ Internal environmental sensitivity (Managers and technicians)
CE policies and regulation	+/– National & internal policies & regulations	+ Be prepared for new regulations
Socio-cultural factors	+ Increase of the company's prestige	+ Better company image
	+/– Pressure from stakeholders	+ Pressure specially from public administration
	– Confidence in the quality of circular product	+/– No evidences detected
Environ. factors	+ Shortage of natural resources	+ Shortage of water resources risk mitigation
	+/– Stakeholder environmental responsibility	+ Local government & customers responsibility
External resources available to the company	+ Business, technic and economic interactions	+ Collaboration of regional clusters & research entities
	+/– Supply chain	+ Involvement of suppliers
	+/– Available public resources	+ Public economic resources for projects (e.g., bioplatforms), distribution network & sewerage

Note: + Drivers, – Barrier, +/– Both. The extended information of the literature review column, as its references, is shown in Table 2.
Source: Prepared by the authors.

the mutual reinforcement between ISO 14001 management system certification and CE adoption has been studied in the literature. Specifically, it is highlighted that the level of CE adoption is positively impacted by the certification of the Environmental Management System and the willingness to improve environmental performance and achieve a sustainable business model (Fonseca et al., 2018; Ronalter et al., 2022).

In line with the results reported in the literature for the adoption of environmental standards, such as ISO 14001 or ISO 14006 (Arana et al., 2013; Bravi et al., 2020; Camilleri, 2022; Fonseca & Domingues, 2018; Heras-Saizarbitoria & Arana-Landin, 2011; Linder & Williander, 2017; Murmura et al., 2018; Murray et al., 2017; Urbinati et al., 2021), the case results highlight cost and capital requirements as the most important barriers to be overcome by companies during the adoption and certification periods.

For the process of adoption and use of the future international ISO 59000 series by companies, the experiences of companies that have adopted and certified their CEPMSs with the reference standard must be of great value. These experiences should serve as a reference to promote and systematise circular business management, including a continuous improvement model. In this way, the overall improvements of the CE in the seven performance areas (sustainable supply, ecodesign, industrial symbiosis, functional economy, responsible consumption, extension of duration, and effective management of end-of-life materials or products) and the three dimensions (environmental, social, and economic) can be measured in a more standardised way, see Table 9. Most of the projects have integrated actions covering several areas, such as the production of energy or raw materials from waste used by the company itself or in industrial symbiosis projects. In all these cases, the need to develop key performance indicators to ensure that their evolution is adequate has been proven. In addition, it is also critical to improve circularity objectives, and the need for capital and liquidity to develop investments.

TABLE 9 Main actions developed by companies to move towards CE management in literature versus by adopting XP X30-901 on CEWT.

Area	Literature review	Case study—CEWT
General	Sustainable development (SD) business strategies and actions	SD objectives include in the strategy
	CE activities and their impact on SD	Major contribution on SDG6 and to lesser extent on 7, 8, 9, 10, 11, 12, 13, 15 and 17
	Certifications to improve environmental performance and CE management	Certification ISO 14001, ISO 50001 and SA 8000
	Biodiversity and env.'s preservation actions	Minimization of extreme weather risks
Sustainable supply	Use env. and social criteria to select suppliers	Purchasing processes with env. criteria
	More efficient use of natural materials	Increase the use of secondary materials and reduce water losses
Ecodesign	Product and process design to enable different CE activities to be undertaken	Bio-drying: natural heating of sludge bacterial biomass
	Redesigning supply chain for product recovery and efficient utilisation of products	Maintenance and new infrastructure supply change
	Product design with SME customers	Collaboration with agricultural clusters to ecodesign fertilisers
	Importance of consumer involvement	Local transport vehicles prepared to use biomethane produced from sludge
	Use of biodegradable materials	Use of processes exploiting biodegradation (methane production)
	Adoption of Environmental Management standard ISO 14006	Ecodesign management system not adopted
Industrial symbiosis	Significant area for the transition to CE	Critical area in several projects
	Initiatives focused on product valorisation	Valorisation of sludge, sand and used water
	Business partnerships for reprocessing	Mainly through local government and agriculture clusters
	Collaboration for waste management	With agricultural, transportation and cleaning firms
	Collaborative env. across the supply chain	Occasional collaborations (not significant)
Functional economy	Product-Service System development	Dissemination of digital culture
	CE business models focused on recovery, reuse, repair or share	Reuse of resources (maintenance and applications linked to meters)
Responsible consumption	Policymakers and SME self-motivation are the main drivers of practices	Strong influence of public authorities
	Biodiversity and envi.'s preservation actions	Work on the network to prevent leaks and weather-related risks
	Support recycling and resource recovery infrastructures	Use of sludge sands in infrastructure improvement works. Importance of predictive maintenance.
	Alternative ways to optimise transports	Sustainable mobility's activities (vehicle fleet of hybrid cars, public transport agreements, co-working sites…)
	Promotion of responsible use of products.	Educational and awareness-raising projects. (Blog, reuse water for cleaning)
Life extension	Reusable containers and packaging.	Increase of *'water-houses'* to fill reusable containers
	Analyse impact of maintenance activities on life extension and environmental impact.	Water collection and purification system for agricultural use and city cleaning
End of their useful life	Actions related with waste management	Increase waste recovery improving separation process
	Reduce landfill waste	Minimization of the sludge sent to landfills
	Use of new smart technologies	Electronic detectors to identify potential risks

Note: The extended information of the literature review column, as its references, is shown in Table 3.
Source: Prepared by the authors.

As can be seen in Table 10, significant improvement in efficiency in the use and consumption of resources are noteworthy. These outcomes were also highlighted in studies relating to the adoption of ISO 14001 and ISO 14006 (Fonseca & Carvalho, 2019; Heras-Saizarbitoria et al., 2016; Landeta-Manzano et al., 2017). The company has had several years of losses in which the investments have not been profitable. However, a positive evolution of the company's economic profitability has been observed, which is expected to compensate for the strong investment made in the long term, mainly through the continuous improvement of efficiency and the new business lines that have been generated. These lines have not been decisive so far, since the company's overall revenues have fallen slightly, but the company expects to be able to make them profitable soon.

Among the main implications of the research, the importance of systematising management to advance in the circular economy is highlighted. The selection of circularity indicators to advance in the three dimensions of sustainability through the continuous improvement cycle is key for decision making, to involve workers, to improve the effectiveness of the process and to obtain results that allow improving the competitiveness of the company in the market. In addition, it is necessary for the public administration to have a tractor effect. To this purpose, it should take advantage of the different tools at its disposal, such as business aid programs, the promotion of sectoral clusters, the drafting of mandatory legislation and/or the design of tender conditions that include circularity indicators, among others.

Regarding the limitations of the research, the level of dissemination of the standard has been a decisive factor that has led us to select and analyse a case study. To minimise the limitations of this methodology to generalise its results, the case has been studied in great depth. This has been possible thanks to the availability of information from numerous internal and external sources, which have been complemented with the opinions of technicians and managers, as recommended by Yin (2018). To minimise the effect of these limitations, the information has been contrasted with other relevant stakeholders (consultants, auditors and agencies involved in the adoption and certification process), as proposed by Patton (2014), Poponi et al. (2019) or Miles et al. (2020) for qualitative data analysis. As for future lines of research, the number of certified companies is expected to grow significantly, and this research could serve as a reference for the design of a multiple case study. Subsequently, it would be combined with quantitative methodologies, to expand the existing knowledge on the adoption of the future ISO 59000 series standards. Another important aspect is to check whether external motivations, such as those derived from public contracts, will continue to be the main source of motivation in the future, and if they vary, to analyse how they affect the results.

TABLE 10 The main CE management results achieved by companies in literature versus by adopting the XP X30-901 on CEWT.

Dimension	Literature review	Case study – CEWT
General	Adopting the CE model allows for more sustainable results	The CE model has allowed them to promote lines of business based on waste recovery
	Adopting CE model does not assure economic and social performances	Stable sales revenues, slight cost reductions and improvements for Stakeholders
	Taxonomy of CE indicators	CEWT assessed as eligible 87.78% of revenues, 85.28% of expenses capital expenditure (capex) and 93.23% of operating expenses (opex) for the year 2021
Economic	Improved corporate reputation, leading to higher financial performance	Best position in tenders because the regional government values the certification
	Practices related to the CE's fields of action do not guarantee positive economic results	Improvements related to CE practices in some income statement items, although there is no evidence that steady positive economic results are a consequence of them
	The implementation of practices related to CE contributes to the economic performance	Improvement in profitability ratios, although there is no evidence that these are related to CE practices
Environmental	Supply chain collaboration, lean practices, energy efficiency measures, reuse and recycling can pay off	Some investments to improve environmental parameters take time to pay off, but they improve efficiency and autonomy
	Advanced management practices or the adoption of environmental management models improve environmental results	The setting of objectives and actions has allowed the improvement of environmental indicators in the 7 areas of action
Social	Human resource actions have a positive effect on companies' employees.	Employees have received training in CE practices
	Knowledge management related to CE could increase employment opportunities	Symbiosis projects have helped generate employment
	CE business models based on product service system increase customer involvement	Strengthened the collaboration with managers of agricultural and public transport companies
	Cost of env. and social practices can hinder social sustainability achievement	Financing problems limit the investments made
	The implementation of practices related to CE contributes to social benefits	Increased the service offered to customers and the community
	CE initiatives contribute to the local economy and social welfare	The symbiosis projects have support local business (agriculture, clean companies, services…)

Note: The extended information of the literature review column, as its references, is shown in Table 4.
Source: Prepared by the authors.

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APPENDIX A

TABLE A1 Summary of the main answers received with the manager and the technician.

	Manager	Technician
Main motivations	Market Public administration Social and environmental effectiveness improvement	Reinforce the company's commitment to the government. Environmental sensitivity
Enablers	Management systems Public administration's commitment Laboratories	Management systems Involvement of stakeholders
Actions	Consult in project documentation developed: 1. Environmental criteria purchase 2. Waste recovery 3. Energy management 4. Biogas energy production 5. Use of reclaimed water. 6. Bio-drying 7. Biomethane for transport 8. Treated water distribution 9. Sludge treatment. 10. Reuse of resources. 11. Rental meters. 12. Consumption management application 13. Purchasing and warehouse management control. 14. Preventive and predictive maintenance 15. Installation of metering elements 16. Water purification 17. - Recovery of elements	
Difficulties	Partnerships Involvement of some suppliers Need of investment	Lack of liquidity
Main results	More control. New business lines. Supply cost reductions. Increase collaboration with public administration and associated organisations. Increase communication with stakeholders. Improve waste management. Increased environmental and social awareness. Waste reduction. Long-term economic opportunities.	Increase the economic stability of the company. Less market risks. Improved market position. Identify opportunities. Be aware of the need to improve the maintenance system. Transform problems into opportunities with some waste. New business with prospects of profitability.
Suggestions for improvement	The government should link taxation to the management of the circular economy. Need to create public funds for symbiosis projects.	To accelerate the circular transformation process, it is necessary to change legislation.

TABLE A2 Summary of the responses provided by the group of experts on motivations, enablers, difficulties, results and suggestions to promote CEPMS.

	Consultant 1	Consultant 2	Auditor	Public administration
Main motivations				
Market	2	2	2	2
Public administration	2	2	1	1
Social and environmental effectiveness improve.	1	1	2	2
Environmental sensitivity	1	1	2	2
Others	Signalling	Image	Signalling	Corporate strategy
Enablers				
Management systems	2	2	2	2
Public administration's commitment	1	2	1	2
Internal infrastructure, laboratories	2	1	2	1
Involvement of some suppliers	1	1	1	2
Advice from auditors, consultants	2	2	2	2
Others	–	Clusters	–	Public programs
Difficulties				
Partnerships	2	2	2	2
Involvement of some suppliers	2	2	2	2
Need of investment	2	2	2	2
Lack of liquidity	2	2	2	2
Others	Staff opposition. Need for training.	Need for training	Fear of change	Need for training
Main results				
More control	2	2	2	2
New business lines	2	2	2	2
Supply cost reductions	1	1	2	1
↑ Collaboration with public administration and organs.	1	1	1	2
↑ Communication with stakeholders.	1	2	2	2
Improve waste management.	2	2	2	2
↑ Environmental and social awareness.	2	2	2	2
Waste reduction.	2	2	2	2
Long-term economic opportunities.	2	2	2	2
Others	Market position	Anticipate legislative changes	Image enhancement. Higher level of warranty.	Anticipate legislative changes
Suggestions for improvement				
Government should link taxation to management of CE	2	2	2	1
Need to create public funds for symbiosis projects	2	2	1	1

TABLE A2 (Continued)

	Consultant 1	Consultant 2	Auditor	Public administration
Legislation changes needed	2	2	2	2
Others	Increase the integration of business models and new technologies.	Promote waste valorisation businesses.	Adapting business to technological change.	Need for higher level of R&D

Note: 0, not agree; 1, partially agree; 2, agree.