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Auditors' environmental proactivity as a driver for waste measurement, accounting, and reporting in a circular economy

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Abstract

Purpose – This study expands knowledge regarding waste accounting processes and the measurement of waste and resource flows for reporting purposes within the framework of Institutional Theory applied to auditing processes in the context of the circular economy.

Design/methodology/approach – The research is conducted from the auditors' perspective through the qualitative analysis of 94 hybrid interviews with auditors in Spain, collected in the second semester of 2024 and the first semester of 2025. As a methodological contribution, the auditors' profiles for waste accounting implementation are analysed through a novel index that integrates the definition of proactivity in accounting and audit processes.

Findings – The results under the institutional theory framework highlight the influence of external pressures, such as regulatory requirements and societal norms, on auditors' behaviours and practices. The growing emphasis on environmental auditing can be seen as a response to increasing regulatory pressures and societal expectations for corporate sustainability and accountability for waste.

Practical implications – Proactive auditors can use specific information on waste and the circular economy to advise their clients on waste accounting practices. Specifically for audits, practitioners are provided with arguments to enhance their environmental proactivity and to help minimise the competitive advantage that large auditing firms have held in assuring sustainability reports in recent years.

Originality/value – This study is one of the first attempts to define and apply the concept of environmental proactivity among auditors, particularly in the context of waste and the circular economy. The results aim to stir an emerging debate on the specificity of waste accounting boundaries within the broader framework of environmental management accounting.

Keywords Waste accounting, Auditors, Circular sustainability accounting, Environmental accounting, Reporting, Sharing economy

Paper type Research article

1. Introduction

Due to the massive volume of resources consumed and the consequent waste generated by global production, companies are growing interested in a circular economy (CE) in a "zero

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waste" scenario (Aranda-Usón *et al*., 2024). The CE is being promoted from multiple areas and institutions to transform the linear model of production and consumption into circular models in which the flows of materials and resources are closed, maintaining their added value for the longest possible time through recycling and valorisation. The waste hierarchy is particularly relevant in an economic model based on closing material loops. Companies are called upon to progressively propose processes that seek to minimise waste as much as possible by differentiating, recycling, and valorising resources and waste for the CE, with the consequent accounting implications (Scarpellini *et al*., 2020).

Some of the studies published to date have comprehensively addressed the analysis of information on CE and waste under different international initiatives, such as the Global Reporting Initiative (GRI) applied to disclosure of non-financial information (García *et al*., 2024), International Integrated Reporting (IIR), or Sustainability Accounting Standards Board (SASB). An increasing number of scholars address CE in accounting (Etxeberria *et al*., 2023), demonstrating the potential of waste streams and resource accounting in the shift to circular model CE with valuation of by-products and waste (Aureli *et al*., 2025).

In the European Union (EU), internal measurement, specific accounting and reporting of waste-related operations take on special relevance in compliance with both the Directive (EU) 2022/2464 (2022) as regards corporate sustainability reporting (CSRD) and the Regulation (EU) (2019) on the establishment of a framework to facilitate sustainable Investment known as the EU Taxonomy. Although the application of the CSRD will be spaced out over time due to the application Omnibus package included in the proposal for a Directive Amending Directives (EU) 2022/2464 and (EU) 2024/1760, 2025) to simplify EU legislation in the field of sustainability (European Commission, 2025), the changes introduced for auditors' roles in the assurance processes of sustainability reports are clearly defined (Bota-Avram *et al*., 2025; Strakova *et al*., 2025).

The European regulation suggests a closer relationship between auditing and environmental accounting, particularly in relation to waste, which is expected to increase its presence in accounting operations gradually. Thus, it is reasonable to assume that auditors, outside the mandatory nature of accounting regulations, are increasingly aware of sustainability issues, like the rest of society and companies themselves, given the pressure from institutions promoting waste reduction in the context of the CE.

These considerations give rise to the research objectives of this study, which aim to expand knowledge regarding waste accounting processes and the measurement of waste and resource flows for reporting purposes within the framework of the Institutional Theory (DiMaggio and Powell, 1983) applied to accounting in a CE (Llena-Macarulla *et al*., 2023). From an institutional theory perspective, differences are observed between voluntary and mandatory environments for auditors as assurance providers, under the requirements of the CSRD (Strakova *et al*., 2025). To address this topic, it is therefore necessary to consider how to resolve the weaknesses of the waste accounting definition and boundaries, since some authors have pointed out inconsistencies with generally accepted accounting principles (GAAP) for waste and related items, either in financial or in non-financial units, due to the absence of generally accepted rules for waste accounting (Evangelinos and Nikolaou, 2011; Kuba-Khoury *et al*., 2025).

A priori, waste accounting sites in the intersection of different accounting areas applicable to waste, such as specific financial accounting rules, and environmental management accounting (EMA) and reporting (Schaltegger and Burritt, 2017). However, given the inability of current accounting systems to comprehensively support CE-related decision-making (Aureli *et al*., 2025; Mersico *et al*., 2025), specific measurement and valuation mechanisms suitable for waste accounting and the auditors' need to be developed in more detail.

Based on the previous arguments, waste accounting and the environmental profile of auditors for waste-related accounting practices must be defined beforehand (RQ1). This first objective is undoubtedly a novel contribution of our study, providing a definition of waste accounting and its specific boundaries within the EMA framework. In addition, the auditors'

profiles for waste accounting implementation are analysed through a novel index that integrates the definition of proactivity in accounting and audit processes (Peecher *et al*., 2024), with the corporate environmental proactivity concept (Garcés-Ayerbe *et al*., 2016; Murillo-Luna *et al*., 2011). We explore the role that auditors can play in the accounting implementation facing the CE, and it partially complements the debate focused on the reliability of sustainability reports from the perspective of accounting practitioners (Boiral *et al*., 2019).

The results obtained through the first objective led us to address a second research question, which aims to analyse the auditors' perception of the extent to which companies measure waste and resource flows within the framework of the CE for reporting purposes (RQ2), in response to the institutional pressure. Finally, as a third specific objective, this study defines and analyses specific waste-related accounting practices from the auditors' perspective and how they could contribute to implementing waste accounts and CE in companies (RQ3). This third field of analysis allows progress in defining the central waste accounting operations necessary to respond to the needs of characterisation, differentiated accounting, and measurement of waste and its valuation (Aranda-Usón *et al*., 2024; Di Vaio *et al*., 2023). The definition of waste accounting and its related practices are understudied, and this paper approaches them to contribute to an emerging debate on the specificity of waste accounting boundaries within the broader framework of environmental management accounting from the auditors' perspective.

The research is conducted from the auditors' perspective through the qualitative analysis of 94 hybrid interviews with auditors in Spain, collected in the second semester of 2024 and the first semester of 2025. The background of the study is summarised in the following section, where the main research questions are introduced. Subsequently, the methodological approach is described to introduce the detailed results presented in the chapter preceding the conclusions.

2. Background

To introduce the background of this study, it is of interest to delve deeper into the definition of what waste accounting encompasses in current business activity, which is evolving to adapt to the demands of the CE, which seeks to optimize resources and minimize environmental impact (Aranda-Usón *et al*., 2020). Thus, the traditional approach to waste management accounting, within the broader framework of EMA, may not be sufficient to encompass the most recent practices for waste and the diversity of recycled materials, by-products, remanufacturing, or valorization activities that are currently being considered. As stated by Puigvert Romia (2023), the current perspective on the treatment that accounting legislation offers for waste, by-products, and environmental issues remains sparse.

As part of the substantive changes in accounting processes for waste resulting from organizational changes prompted by the environmental crisis (Larrinaga-Gonzalez and Bebbington, 2001), Qian and Burritt (2007) extended environmental accounting to waste management, based on the idea that accounting for waste requires direct monetary and physical flow information. However, despite the growing interest in this topic, the definition and analysis of waste accounting is little explored outside the EMA framework. Thus, we argue that accounting scholars should urgently participate in the debate about the conceptualization of waste accounting, as a more specific topic than the broader environmental accounting framework in which it has been primarily developed.

In this framework, we define waste accounting as the specific accounting processes relevant to waste regulation applications, financial accounting entries, financial reports, internal accounting practices, and the measurement of waste-related sustainability indicators to inform decision-making processes and sustainability reporting purposes. As a basis for this definition, it is considered that waste accounting represents an intersection of National and International Financial Reporting Standards (IFRS), International Accounting Standards (IAS), and the management accounting area, encompassing all internal accounting practices

associated with waste. We thereby open a debate on the development of accounting practices for waste from both academic and professional perspectives. This study approaches the topic from the auditors' perspective, considering their environmental profile to promote more advanced waste accounting practices among companies through auditing processes in a CE context.

2.1 Environmental proactivity of auditors

The introduction of sustainability pillars within production and consumption patterns is influencing the accounting profession, which is undergoing a significant transformation, as traditional practices are being reevaluated to incorporate environmental considerations (Pramukti, 2024). The analysis of the literature on circular accounting confirms the high level of interest among accountants and the importance of this topic (Gallardo-Vázquez and de la Cruz Sánchez-Domínguez, 2023; Vysochan *et al*., 2024). However, defining and analysing the concept of environmental proactivity regarding auditors' practices and values is an understudied topic. Factors such as auditors' tacit knowledge related to sustainability accounting and standardised frameworks for sustainability measuring and reporting remain underdeveloped and reliant on.

On a topic close to our research, Rakipi and D'Onza (2024) demonstrate that the internal audit function has a minimal role in assuring environmental, social, and governance (ESG) processes. Through 31 interviews, these authors affirm that internal auditors must adapt their activities to stay aligned with the company's evolving requirements, which may include facilitating the implementation of ESG processes, sustainability objectives, and assurance over the entire ESG risk management, in line with Darnall *et al*. (2009).

The differences between large and small assurance providers make a more prominent professional differentiation between consulting and the professional identities of accounting and firms (Boiral *et al*., 2020). Notably, Eulerich *et al*. (2022) have analyzed the imbalance between assurance and internal auditing functions highlighting the complementary relationship between internal auditors and external assurance in ESG disclosure. These authors reflect on how internal auditors can engage in ESG while maintaining their independence and note an overall lack of specific guidance for internal auditors on sustainability issues.

In this framework, Liu *et al*. (2023) specifically analyze the auditor-client sustainability alignment by measuring auditors' sustainability focus in their tweets on Twitter. As a result, these authors suggest that auditor sustainability focus is positively associated with the operational management of sustainability issues. Despite the undeniable interest in this work, it does not provide a specific definition of the auditors' profile regarding sustainability, waste, and CE that is necessary for the first research objective of our study.

From a perspective closer to our investigation, Liu *et al*. (2020) explore the antecedents of internal auditors' voices in environmental-related issues. They found that internal auditors' perceived organisational environmental orientation and their own are significantly related. Internal auditors' voice in environmental-related issues depends on their ecological values and commitments.

From another perspective, Fernandez-Feijoo *et al*. (2018) discuss the generalised choice of Big4 as a financial auditor and assurance provider, suggesting their potential competitive advantage. Considering this idea, we suggest that other auditing firms could overcome their disadvantages in the future through specific knowledge about waste and CE. This specialisation could also mitigate the effects of sustainability reporting on auditors' judgment and overcome certain auditor conservatism (Tuo *et al*., 2023).

Currently, internal auditors are not required to perform specific sustainability, CE, or waste procedures that do not affect material issues for financial reporting. Nevertheless, building on the basis proposed by Liu *et al*. (2023), we argue that auditors with higher expertise and knowledge of CE and material flow measurement can enhance the reliability of sustainability information.

Given these premises, we opt to integrate the concept of proactivity in accounting audit processes (Peecher *et al*., 2024) with the corporate environmental proactivity developed in the framework of environmental strategy (Garcés-Ayerbe *et al*., 2016; González-Benito and González-Benito, 2006; Murillo-Luna *et al*., 2011). The auditors' environmental proactivity can be defined as their commitment to environmental and sustainability considerations. In particular, we apply this general concept to the auditor's behaviour, integrating the environmental issues in auditing through tacit knowledge and the environmental focus into the auditing processes. In our case, proactivity could include ESG, GRI, and SASB, suggesting leveraging forward-looking metrics, the EU CRSD, the EFRAG standards, the EU Taxonomy for sustainable finance, and the CE models.

This topic has been little explored to date in the accounting literature. Given the standardisation gap, this research explicitly delves into the positioning of auditors regarding CE and waste streams for circularity, raising the first research objective to define and measure the level of environmental proactivity of auditors, specifically their knowledge inherent to CE and waste for circularity (RQ1).

This first research objective enables us to define the profile of accounting auditors based on their level of involvement and awareness of environmental issues, and subsequently to gather their opinions on the extent to which companies accurately measure waste and resource flows within the framework of the CE for their accounting and reporting purposes.

As stated by Alrazi *et al*. (2015), environmental proactivity is not new in the literature (González-Benito and González-Benito, 2006). It involves different components of environmental management systems and certifications (Valero-Gil *et al*., 2024), as well as environmental accounting aspects to cover all areas of accounting related to environmental issues (Gray and Bebbington, 2001). Environmental accounting includes financial accounting (accounting for contingent liabilities/risks, accounting for assets, valuations, etc.), management accounting (e.g. costs, capital items and revenue, cost/benefit environmental improvement, CE, waste accounting, performance measurement and incentives), and auditing (e.g. internal environmental audit, environmental impact assessment, and external assurance of sustainability reports). However, as of the last changes normative in the EU where the clear relationship between internal auditors and assurance processes is stated, we need to go beyond the sections accounting classics environmental and investigate whether the internal audit functions can significantly enhance both measurements related to financial auditing functions (in this case for waste and the CE) and reporting specific issues for waste in the sustainability framework.

2.2 Measuring and reporting waste in circular environments

The evolution of accounting practices for the transition towards a low-carbon and zero-waste economy is emphasised, with waste management being particularly relevant for closing material loops in CE models (Di Vaio *et al*., 2023; Salesa *et al*., 2023). However, there are very few that analyse accounting processes from the CE perspective and explicitly define the accounting implications of waste.

Recently, there has been an increase in the accounting literature related explicitly to CE models (Arjaliès *et al*., 2023; Etxeberria *et al*., 2023) within the framework of environmental accounting for resources (Jesse *et al*., 2023; Jørgensen *et al*., 2023; Svensson and Funck, 2019), management accounting applied to circular models, material flows, and waste (Bux and Amicarelli, 2022; Marco-Fondevila *et al*., 2023; Pratt *et al*., 2016; Salesa *et al*., 2023; Taleb and Al Farooque, 2021), analysis of the CE within sustainability accounting frameworks (Gallardo-Vázquez and de la Cruz Sánchez-Domínguez, 2023; Larrinaga and Garcia-Torea, 2022), or accountability and reporting for CE (Alfatlah *et al*., 2021; Costa *et al*., 2023; Moneva *et al*., 2023; Rabasedas *et al*., 2023).

Given these premises, we can affirm that few specific accounting studies still focus on waste and CE (Aranda-Usón *et al*., 2024). This research addresses the measurement, accounting, and reporting gap for circular processes and waste.

Our study, which is of an eminently applied nature, does not have as its primary objective to make a theoretical contribution. However, given the consideration of more significant institutional pressure in the EU towards a zero-waste economy and the growing obligation to report on the progress made by organisations in closing material loops (Directive (EU) 2022/2464, 2022; Commission Delegated Regulation (EU), 2023) the background of this study is based on the general framework of Institutional theory (DiMaggio and Powell, 1983).

Wang *et al*. (2014) investigate the quality of CE accounting disclosure within this theoretical framework and conduct an empirical analysis of the relationship between accounting disclosure for CE management and institutional pressure.

Roberts *et al*. (2023) apply the Institutional theory for biodiversity analysis in a CE framework and point out that some studies are also based on the application of the CE (Ranta *et al*., 2018; Jain *et al*., 2020). More specifically, Vysochan *et al*. (2024) state that accounting processes related to the CE and their increasing complexity are becoming increasingly relevant. Llena-Macarulla *et al*. (2023) consider that regulations regarding CE measurement and reporting are still relatively recent, so institutional theory could partially explain the implementation of environmental accounting practices in businesses and reporting in a circular scenario (Marco-Fondevila *et al*., 2020). Thus, this research draws on this theoretical background to assess the institutional pressures for CE-related accounting systems and to achieve legitimacy in a zero-waste environment. This general consideration is applied to internal auditing processes, building on the seminal study by Di Vaio *et al*. (2023), who initiated the debate about the role of accounting and reporting in CE and waste through a literature review.

In addition, Pramukti (2024) states that institutional pressures play a significant role in driving the adoption of environmental auditing practices within organisations, as evidenced by a systematic review of the literature on environmental auditing. Regulatory bodies impose requirements for environmental disclosures and audits, compelling organisations to comply with regulations (O'Dwyer and Unerman, 2008).

For this reason, a second research question aims to contribute to this topic from the auditors' perspective, seeking to determine the extent to which companies specifically measure and account for waste flows from a circular approach (RQ2) and the institutional pressure for reporting, as perceived by auditors.

This analysis, based on the general idea that institutions exert pressure on companies, and therefore on auditors, enables us to subsequently reflect on the role of these professionals in accounting processes related to waste and CE.

2.3 Waste accounting practices in a circular economy and the role of auditors

Given the changes promoted by the EU for the drastic reduction of waste, it is necessary to expand the knowledge of academic literature regarding accounting processes and respond to the needs of measuring, accounting for, and reporting material flows, resources, and waste in circular models beyond general accounting resolutions and national regulations.

In a CE framework, waste increasingly absorbs the costs associated with its treatment and recycling, thereby extending the value of the materials as much as possible by progressively slowing down and closing the material loops. The relatively lower importance of waste operations in accounting processes and the present analytical result foreshadow an evolution in business practices in response to the reporting requirements of international and EU standards.

In this scenario, integrating circular principles in accounting practices and measuring and reporting aspects related to CE within companies is essential, among other issues, for the evolution of the so-called "circular sustainability accounting" (Aranda-Usón *et al*., 2022). However, Arjaliès *et al*. (2023) highlight the multiple barriers that hinder the adaptation of accounting practices to CE designed for a linear production model (Kwarteng *et al*., 2023). Although some companies are introducing certain specific internal accounting management actions related to circular models, and the gradual implementation of reporting methods and

processes have been observed, related explicitly to CE (Llena-Macarulla *et al*., 2023; Marco-Fondevila *et al*., 2021), cases where accountants are directly involved in the implementation of CE are still rare (Halari and Baric, 2023). In addition, it is expected that the emerging intersection of blockchain and accounting, as noted by Parra-Domínguez *et al*. (2025), will also impact waste and CE accounting practices.

Given the above considerations, auditors are poised to bridge the gap between existing and proposed frameworks, sustainability guidance, and clients' sustainability reporting (Liu *et al*., 2023). As sustainability is a strategic firm issue, auditors can facilitate the role of accounting in assessing the environmental, social, and governance outcomes of firm operations and their broader societal impact. Thus, one objective of this paper is to expand knowledge about what auditors can play in adapting environmental accounting to the challenges of the CE.

The topic is not entirely new, although it has not previously been specifically developed within the framework of waste accounting and CE. For more than a decade, research on the contribution of internal auditors to sustainability services has been suggested by Ridley *et al.* (2011) for both developed and emerging markets. However, few empirical internal auditing case studies about this auditor's role still exist. Alajeli and Wahhab (2022) demonstrate the role of internal audits in evaluating sustainable performance and its impact on financial report quality using the balanced scorecard in the automotive sector. Yalçın (2024) highlights the critical role of the auditing profession, which could include the analysis of environmental practices and disclosures of the audited organisations. The cited authors aim to reflect on how auditors can integrate organisations' sustainability initiatives using standardised reporting frameworks to overcome constraints in their independent assessments that only consider emissions and general environmental impacts regulated by general accounting rules.

From another perspective, Pramukti (2024) highlights several challenges hindering the effective integration of environmental aspects into auditing practices, including the need for standardised methodologies and metrics for assessing environmental performance, the complexity of environmental regulations across jurisdictions, and the inherent subjectivity involved in evaluating qualitative aspects of sustainability. Furthermore, auditors may face resistance from management, who are reluctant to disclose sensitive environmental information or invest resources in sustainability initiatives (Pramukti, 2024). Thus, integrating environmental aspects into auditing practices represents a multifaceted and dynamic field with implications for sustainability, which is also applicable to circular business models (Scarpellini, 2022).

However, auditors' work in this field presents both challenges and opportunities, and it remains an underexplored topic in the literature. This raises the third research objective, which focuses on analysing the main waste accounting practices adopted by audited companies and the potential role of auditors in promoting specific accounting practices inherent to waste and the CE (RQ3).

3. Research design

To achieve the main research objectives, the methodology was based on a qualitative approach comprising 94 hybrid interviews with auditors in Spain. These hybrid interviews combine techniques typical of open and semi-structured interviews with the background and objectives of the Likert scale, as performed in previous studies on circular accounting (Aranda-Usón *et al*., 2024; Portillo-Tarragona *et al*., 2025). Thus, the hybrid method included both open-ended and multiple-choice questions, as well as Likert-scale questions. The interviews were structured to capture the knowledge of auditors on sustainability, waste management, and the CE, as well as to gather the auditors' opinions on waste-related accounting practices and the relevance of measuring material flows and waste for reporting in audited companies under the institutional pressure.

According to other authors (Strakova *et al*., 2025), hybrid interviews are considered a valid source for collecting the auditors' perspective, given the lack of specific databases about audit processes and auditors' knowledge regarding sustainability and the CE. A previous study limited to the auditors' profile in terms of sustainability applied a qualitative semi-structured interview method and analyzed the audit companies' activity on Twitter and social media (Liu *et al*., 2023). The results of Sarens and Lamboglia (2014), within scope but without reference to environmental aspects, are presented here bring strategic human resource management into the auditing process. These authors used a questionnaire completed by a sample of 280 members of the Institute of Internal Auditors in Belgium (17.3% response ratio) to analyse their level of education, work experience in auditing, and other variables regarding the auditors' profiles. Likewise, Strakova *et al*. (2025), recently conducted 21 interviews to capture motivation for providing the assurance of sustainability information under the CDRS.

Other authors surveyed Chinese auditors (Liu *et al*., 2020) using 226 responses (out of a total of 417), and their immediate supervisors, including questions related to waste or CE issues, which we included in the 107 internal surveys that auditors carried out by Eulerich *et al*. (2022). These Authors provide empirical evidence about the internal auditor's role in ESG disclosure and assurance, yet highlight the lack of aggression about internal auditing responsibilities in ESG matters. Likewise, Sarens and Lamboglia (2014) propose an approach to laws and regulations, grounded in a veiled concept of proactivity for auditors, or acquiring knowledge of the business. However, the hybrid method proposed in our study addresses unprecedented questions about waste accounting and the CE.

3.1 Interviews and auditors' profiles

Specific aspects of the aforementioned studies served as the basis for developing the hybrid interviews used in our analysis. However, given the different approach, we opted to develop an entirely new interview in their wording, formulation, and set of questions (Table 1).

Table 1 includes a first section to measure the level of environmental proactivity of auditors (RQ1). The second section includes two sets of questions: one related to institutional pressure and another to analyse the measurement of waste and resource flows for reporting purposes in audited companies (RQ2). Finally, the third section of the hybrid interview is structured to define specific waste accounting practices introduced by companies from the auditors' perspective, and how these professionals could contribute to implementing waste accounts and CE in companies (RQ3).

Time constraints imposed on the auditors affected the collection of responses, which were often carried out online, with an average response time of 20–30 minutes. To minimize the duration of the response, questions were sent in advance to auditors and their responses were collected through two channels. The open-ended questions were transcribed in writing, and the multiple-choice and Likert scale answers were provided directly by the interviewees.

Regarding selection bias, respondents were randomly selected among auditors attending technical and training workshops throughout Spain, whose personal data are available on request due to confidentiality reasons. The interviewees' profiles and levels of training are presented in Figure 1.

It can be observed that most interviewees hold a university degree, and among the youngest, those with specific postgraduate studies in a university master's degree in auditing stand out, in line with the current requirements in Spain for professional practice.

The obtained answers were analysed using different qualitative methodologies to perform a statistical-descriptive and relational analysis, classifying and aggregating the responses obtained. A content analysis identifies recurring segments and patterns in the responses to open-ended questions, which have been previously transcribed into text.

The exploratory results indicate that respondents do not exhibit a greater interest or sensitivity to sustainability. For instance, just 47% of participants believe that sustainability information should be externally verified in all cases (ASSUR item). Furthermore, following

Table 1. Variables and primary questions of the hybrid interview applied to this study

Variable	Interview questions	Variable types
Auditors' environmental proactivity index (RQ1)		
CSRD	*To what extent is the interviewee aware of the CSRD Directive (EU) 2022/2464?*	Likert scale from 0 to 10, where 0 is nothing or to a small extent, 10 is totally or to a great extent; NA
EFRAG	*To what extent does the interviewee know the EFRAG standards Delegated Regulation (EU) 2023/2772 CSRD application*	
TAXO	*Sustainable Finance Taxonomy Regulation (EU) 2020/852*	
SDG	*To what extent does the interviewee know the United Nations SDGs?*	
InfSUSTtxt	*Interviewee's opinion on the sustainability information provided by companies*	OPEN QUESTION
ASSUR	*Respondents who believe that sustainability information should be externally verified in all cases*	Dichotomous YES/NO
DONE	*Respondents who claim to have already verified sustainability information at some point*	Dichotomous YES/NO
Analysis of institutional pressure (RQ2)		
CE-EU	*To what extent does the interviewee know the new Action Plan for the Circular Economy of the European Union (year 2020)*	Likert scale from 0 to 10, where 0 is nothing or to a small extent, 10 is totally or to a great extentNA
PresEU	*Pressure from EU institutions through regulation*	
PresESP	*Pressure from the central and/or regional government through regulation*	
PresICAC	*Pressure from ICAC (Institute of Accounting and Auditing of Accounts) and national standards*	
PresSTAN	*Pressure from the adoption of international standards*	
Other	*Other information not mentioned above*	OPEN QUESTION
Waste measurement in companies (RQ2)		
CHAIN	*Opinion on whether companies measure actions for sustainability in the value chain*	Likert scale from 0 to 10, where 0 is nothing or to a small extent, 10 is totally or to a great extentNA
FLOORING	*Opinion on whether companies measure resource inflows*	
FLOUT	*Opinion on whether companies measure resource outflows*	
WAST	*Opinion on whether companies measure waste and emissions*	
WORTH	*Opinion on whether companies have a strategy for resource valorisation*	
BEEF	*Opinion on whether companies measure energy flows and renewable energy, or green electricity*	
Auditor role analysis (RQ3)		
BARR	*What are the main barriers that auditors encounter when analysing sustainability information?*	OPEN QUESTIONS
TIMEINF	*Interviewee's opinion on the time frame in which companies measure information to a greater extent, and on how to encourage it*	
TIME	*Interviewee's opinion on the time frame in which companies will increase measurement and information on sustainability*	

(*continued*)

Table 1. Continued

Variable	Interview questions	Variable types
Accounting practices for waste and CE (RQ3)		
EXPINV	*Classification of environmental expenditure and investments (subaccounts)*	Likert scale from 0 to 10, where 0 is nothing or to a small extent, 10 is totally or to a great extent; NA
VALMAT	*Specific classification and valuation of recycled and/or recovered raw materials*	
VALWAST	*Classification and specific assessment of waste for recycling*	
ACCOUNT	*The accounting department's role in collecting internal data on sustainability*	
LCA	*Implementation of life cycle analysis (LCA) tools*	
SHAR	*Calculation of specific costs of the company's participation in collaborative " sharing" models*	
MFCA	*Implementation of UNE-EN ISO 14051 on material flows*	
FOOTPR	*Carbon footprint measurement or similar*	
Other	*Other information not mentioned above*	OPEN QUESTION

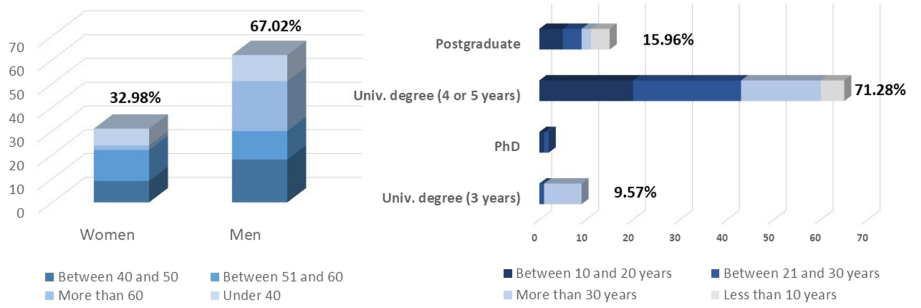

Figure 1. Profiles and ages of the interviewees (figure on the left) and level of education classified by years of audit experience (figure on the right)

other authors (Chaudhuri and Holbrook, 2001; Diamantopoulos and Siguaw, 2006; Poppo and Zenger, 2002), who built upon the initial proposal by Armstrong and Overton (1977), we compared the early respondents = 46) and late respondents (n = 48) in terms of the quantitative variables. All differences were not significant at 0.09 (the lowest p-value). Selection bias was therefore not considered as a relevant issue in this methodology.

4. Main results

Based on the preliminary analysis of the definition of waste accounting and its integration into environmental accounting and EMA, as provided in the background chapter, the following sections present the main results obtained through hybrid interviews with auditors.

4.1 The proactivity index

In response to the first research objective, the level of environmental proactivity of auditors (RQ1) is defined by instrumenting a construct from the variables in Table 1 that allow us to analyse their level of knowledge of sustainability issues, or waste-related regulation and the CE, such as the CSRD Directive [CDRD], the EFRAG standards [EFRAG] of Delegated

Regulation (EU) 2023/2772 implementing CSRD, the EU Sustainable Finance Taxonomy [TAXO], or the SDGs [SDG].

The interviewee's opinion is also collected through an open-ended question concerning the application of sustainability principles [InfSUSTtxt] in auditing. In addition, the environmental proactivity of auditors is assessed by two further questions regarding external assurance of sustainability reports, specifically whether it is considered relevant regardless of whether it is mandatory or not [ASSUR], and their professional experience in assurance [DONE].

The results obtained are summarised in Table 2, which shows the low average scores regarding the auditors' mastery of EU standards and regulations (on a 10-point Likert scale). In addition, it is noteworthy that 44 respondents (46.8%) consider that assurance of sustainability reports must be carried out in any case, and 21 auditors (22.3%) have already carried out the assurance.

Most auditors have low or very low levels of knowledge about the issues raised in sustainability, expressing their closeness to the SDGs. Directive (EU) 22/2464 is slightly better known than the other standards and regulations mentioned. The low percentage of auditors with experience in assuring sustainability reports (now updated to 22.3%, adding the total number of recollected interviews) is particularly pertinent and accurately reflects the regulatory framework and market conditions existing at the time of the study in Spain and the EU.

Traditionally, reporting sustainability was a voluntary action for companies or, at best, regulated under a flexible scheme through the Non-Financial Disclosure Directive (NFRD, 2014/95/EU). Thus, the assurance of non-financial information was not mandatory in most Member States, or mandatory in limited cases and with high limits. When it was performed, the assurance of non-financial reports was frequently outsourced to specialized providers other than the traditional financial auditor, usually standards-certifying bodies or consultancy firms (e.g. *Big4*), and its scope was limited to a moderate and limited assurance.

For the development of the environmental proactivity index, as a first approach of this type in relation to the auditors' profile, the Likert scale scores over ten assigned by auditors to the variables [CSRD], [EFRAG], [TAXO], and [SDG] are integrated (40 points) and a five-point score is added in case of a positive response to variables [ASSUR] and [DONE], for a maximum total score of 50 points as proactivity value. The results obtained are classified into 5 levels of proactivity based on the percentage of scores given by the interviewees to the variables that integrate the index as shown in Table 3: Very High (+80%); High (60%–80%); Medium (40%–59%); Low (20%–39%); Very Low (<20%).

As expected, given the incipient application of EU regulations, most auditors are at low or very low levels of proactivity, with only four interviewees achieving a score of more than 80%.

Table 2. Responses obtained regarding the interviewees' mastery of EU standards and regulations on sustainability and reporting

	CSRD	EFRAG	TAXO	SDG
MEAN	4.4	3.9	3.4	4.5
MEDIAN	4.0	3.0	2.0	4.0
Std dev (SD)	*2.8*	*2.6*	*2.7*	*3.2*
MODE	*3*	*3*	*2*	*2*
High level (8–10)	15	10	8	27
Medium level (4–7)	35	31	30	24
Low level (1–3)	34	42	41	31
No Knowledge	10	11	15	12
ASSUR	*YES:*	*44*	*NO:*	*50*
DONE	*YES:*	*21*	*NO:*	*73*

Table 3. Number of responses obtained at each level of the auditors' environmental proactivity index and their percentage

Environmental proactivity index Level	*N.* of auditors	%
Very high (+80%)	9	*9.6%*
High (60%–80%)	18	*19.1%*
Medium (40%–59%)	11	*11.7%*
Low (20%–39%)	27	*28.7%*
Very low (<20%)	29	*30.9%*
Total	94	

To analyse internal consistency and structural validity of the index, additional analyses were performed. Considering the structure and items integrated into the proactivity index, we conducted an exploratory factor analysis (EFA) due to its application as a preliminary analysis in the absence of a sufficiently detailed theory regarding the relationship between the indicators and the underlying constructs (Gerbing and Anderson, 1988). Principal component analysis was used to confirm the underlying structure of the index. The EFA results (Figure 2) confirm the presence of a second-order factor that integrates the six proposed items, even if the number of observations is limited for a covariance-based Structural Equation Modeling (SEM).

Figure 2 also includes the fit goodness indicators of a Confirmatory Factor Analysis (CFA) for the estimation of the KNOWLEDGE construct.

4.2 Measurement for reporting and institutional pressure

For the second research question (RQ2), the auditors' perspective is analysed to determine to what extent the audited companies specifically measure and account for waste flows from a circular approach for reporting. To this end, Table 4 summarises the responses obtained for the

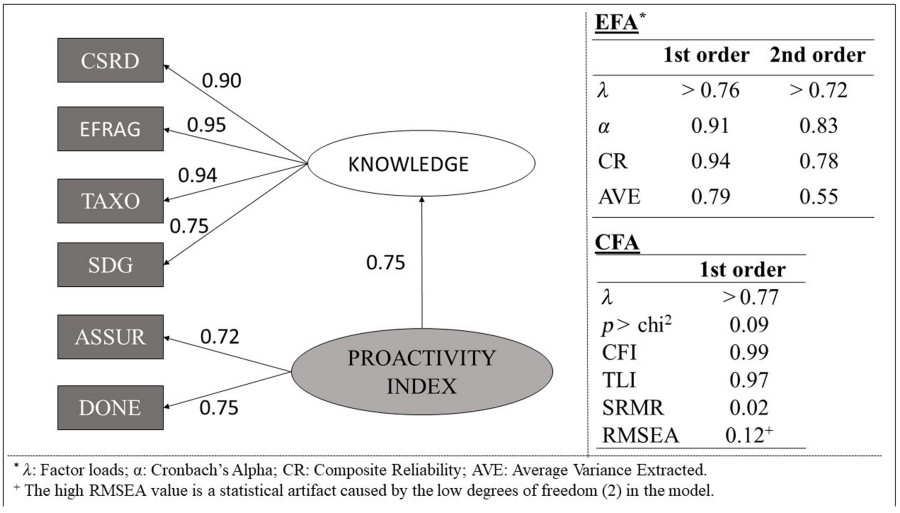

Figure 2. EFA analysis to analyse second-order factors of the proactivity index

Table 4. Measurement of material and waste flows in the companies audited by the interviewees, along with the average based on their professional experience (in years)

	CHAIN	FLOORING	FLOUT	WAST	VALUE	RES
MEAN	2.6	2.8	2.8	4.0	3.0	3.1
MEDIAN	2.0	2.0	2.0	3.0	3.0	2.0
MODE	*1*	*2*	*2*	*3*	*0*	*1*
Std Dev (SD)	*2.3*	*2.3*	*2.4*	*2.8*	*2.4*	*2.7*

Years of experience	CHAIN average	FLOIN average	FLOUT average	Average WAST	Average VALUE	Average RES
Less than 10	2.38	3.38	3.00	5.00	2.50	3.00
Between 10 and 20	2.35	2.46	2.42	3.77	2.85	3.35
Between 21 and 30	2.90	3.04	3.04	3.71	2.86	2.85
More than 30	2.74	2.65	2.69	4.11	3.33	3.19

variables [CHAIN] of the level of measurement of sustainability in the value chain, the variable [FLOIN] to find out whether companies measure input flows of resources and [FLOUT] for output flows; the variable [WAST] through which the responses about the level of measurement in companies of waste and emissions are collected; the variable [VALUE] to gather the opinion of the interviewees on whether companies have a strategy for the valorisation of resources; and the variable [RES] on the measurement of energy flows and renewable energies or green electricity by companies.

This second analysis confirms that practices for measuring material and waste flows as input and output, according to EFRAG standards in CE environments, are still scarce in audited companies (Table 4).

To reflect on the pressure exerted by institutions in terms of sustainability reporting and CE, the auditors' perception of the EU Action Plan for CE [CE-EU], the pressure from EU Institutions through regulations on sustainability and reporting [PresEU], the same pressure at the national and regional level [PresESP], the pressure perceived by the Institute of Accounting and Auditing of Accounts in Spain [PresICAC]; and the pressure relating to international standards for information and reporting on sustainability [PresSTAN] are analysed using a Likert scale (between zero and 10). The results are summarised in Table 5, highlighting higher scores than those received in Table 4, except for the European CE regulation, which is scarcely known among the interviewees.

4.3 Measurement for reporting and institutional pressure

To define and analyse the relevance of main waste-related accounting practices introduced by companies (RQ3), the auditors' opinion is summarised in Table 6.

There is a considerable uniformity in the level of implementation of the waste-related accounting practices analysed, although with slightly higher scores in the classification of

Table 5. Interviewees' perception of institutional pressure

	PresEU	PresESP	PresICAC	PresSTAN	CE-EU
MEAN	7.6	7.0	5.3	6.8	6.8
MEDIAN	8.0	7.0	6.0	7.5	7.0
MODE	*7*	*8*	*5*	*8*	*8*
Std Dev (SD)	*1.8*	*2.2*	*3.1*	*2.5*	*2.3*

Table 6. Opinion of the interviewees regarding the implementation of the main waste-related accounting practices and the CE

	EXPINV	VALMAT	Valwast	Account	LCA	SHAR	MFCA	Footpr
MEAN	7.3	6.8	6.7	7.0	6.5	5.9	5.6	7.1
MEDIAN	7.0	7.0	7.0	7.8	7.0	7.0	6.0	7.0
Std Dev (SD)	*4.8*	*3.6*	*3.7*	*4.9*	*3.9*	*2.9*	*3.0*	*4.3*
MODE	*7*	*7*	*7*	*8*	*8*	*7*	*7*	*7*
High level (8–10)	44	30	31	44	33	18	18	39
Medium level (4–7)	38	48	47	33	41	51	44	38
Low level (1–3)	5	6	7	8	8	9	12	9
Zero or NA	7	10	9	9	12	16	20	8

environmental expenses and investments [EXPINV] and in the valuation of recycled or valued raw materials [VALMAT], with lower scores having been obtained for the applications of specific tools such as life cycle analysis [LCA] or material flow cost accounting [MFCA]. Although collaborative practices [SHAR] have been detected, they are also among the lowest in this analysis (Table 6).

To define the potential role of auditors in fostering waste accounting practices among companies, the above accounting practices are categorized by calculating the average value assigned by each interviewee to the eight variables. The quantitative result (Figure 3) is confirmed through an Analysis of Variance (ANOVA) test, using the factor [1] of waste accounting practices items as the dependent variable and the categorized level of proactivity (factor) as the independent variable (Table 7). The estimation results confirm the lack of any clear differences between groups ($F = 1.436$, p-value>0.23).

Table 7 summarises the factorial analysis of proactivity index construction and accounting practices.

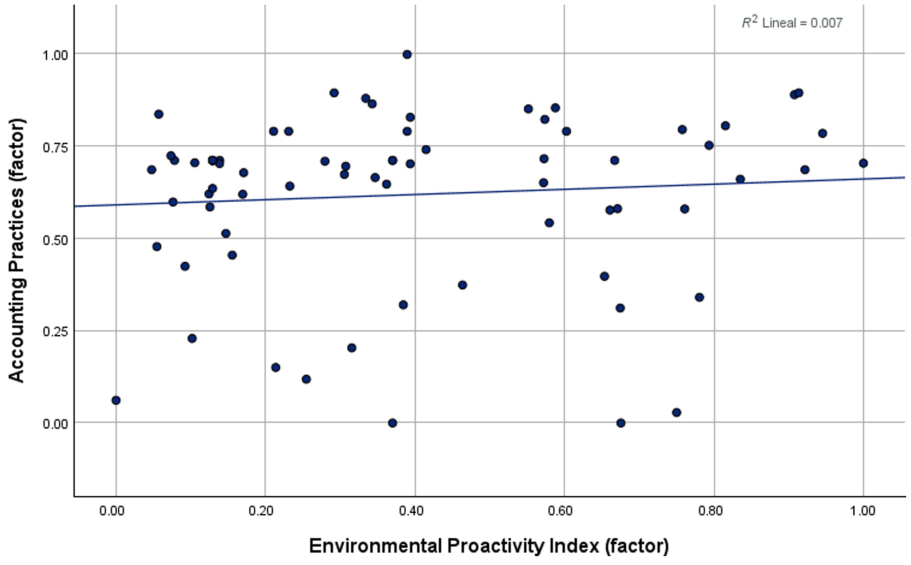

Figure 3. Relationship between the factor of the accounting practices and the level of environmental proactivity of the auditors (factor)

Table 7. Comparison between the levels of implementation of accounting practices (factor) and the levels of environmental proactivity of auditors

Level of proactivity	Very high >80%	Medium 40–59%	Low 20–39%	Very low <20%	High 60–80%	Total
Level of waste accounting	0.77	0.69	0.60	0.60	0.55	*0.62*

Finally, based on the results obtained and through the analysis of the open questions, some arguments are raised for discussion.

4.4 Some discussion notes

As a general consideration, we observe that the analysis under the institutional theory framework highlights the influence of external pressures, such as regulatory requirements and societal norms, on auditors' behaviours and practices. The growing emphasis on environmental auditing can be seen as a response to increasing regulatory pressures and societal expectations for corporate sustainability and accountability in line with Pramukti (2024).

Our study contributes to the debate highlighted by Ridley *et al*. (2011) and Eulerich *et al*. (2022) in defining standardised guidance for internal auditors on sustainability issues to maximise the internal auditing functions. Furthermore, we found that auditors may face resistance from management, who are reluctant to disclose sensitive environmental information or invest resources in sustainability initiatives (Pramukti, 2024).

We confirm the connection between the financial auditor and the sustainability reports assurer (Fernandez-Feijoo *et al*., 2018)which enhances the proposals by Boiral *et al*. (2020) regarding the professional requirements for internal auditors to integrate the practice of assurance for sustainability reports into their auditing processes. This result points out that it could also be interesting to analyse the connection between financial auditors and assurance providers and the role of big accounting firms in the EU's new market for assurance in line with Strakova *et al*. (2025).

Larrinaga *et al*. (2020) reveal a significant influence of non-Big4 firms (mainly certification bodies and consulting and engineering firms) on the diffusion of sustainability assurance disclosure norms, which is influenced by national contexts. Our findings in this research therefore suggest a link with these previous results by Larrinaga, due to the increasing environmental proactivity of auditors, suggesting that these professionals are enhancing their skills in sustainability for assurance activities in the near future, being a "window into the whole company" (Rakipi and D'Onza, 2024). To date, academics and practitioners have not agreed on the internal auditing responsibilities in ESG matters. However, our results are inconsistent with the considerations of prior research on internal audit outsourcing practices, which show an increasing preference for external consultants when specialized skills are required for internal auditors (Rakipi and D'Onza, 2024).

Our approach differs from that proposed by Tuo *et al*. (2023) which suggests that non-reporting firms are more likely to receive a going-concern opinion than reporting firms. We confirm the results obtained by Liu *et al*. (2020) because if auditors perceive their involvement in sustainability-related issues, their sense of organizational environmental value improves. So far, internal auditors' voice in environmental-related issues also depends on their environmental values and commitments.

Although it is not statistically proven, from the auditors ' perspective, our findings lead to the idea that greater environmental proactivity on the part of these professionals favours disclosure by companies. We argue that auditors with higher expertise and knowledge of CE and material flow measurement can increase the reliability of sustainability information

(Liu *et al*., 2023). A greater auditor sustainability focus, where sustainability is a key issue for the auditor, could lead to additional sustainability discussions within the context of the main audit engagement. As such, clients already planning to ramp up their sustainability reporting and have a greater sustainability focus could, therefore, seek out and match themselves with auditors demonstrating a greater sustainability focus. Thus, we enhance the definition of environmental accounting (Alrazi *et al*., 2015).

Notably, challenges remain because environmental auditing offers significant opportunities for enhancing organizational transparency, accountability, and resilience in the face of environmental risks and opportunities. However, the landscape is undergoing a substantial transformation with the CSRD Directive that significantly expands the number of entities required to report sustainability information, establishes the mandatory use of the European Sustainability Reporting Standards (ESRS), and introduces, as a central aspect, the requirement for external and independent assurance of sustainability information. Initially, the assurance is being limited to a moderate level of assurance, although the CSRD Directive contemplates a future transition to reasonable assurance, similar to that required for auditing financial statements.

The transposition of the CSRD Directive into Spanish law, with its implications for key regulations such as the Spanish Audit Law, will require thousands of companies to submit their sustainability reports for external assurance by duly accredited auditors or independent providers. In this sense, the empirical data reflected in this study sample should be interpreted as a snapshot of the context prior to the implementation of these new obligations. However, this widespread lack of prior experience highlights one of the main challenges that the auditing profession will face in the coming years. Hence, the development of specific competencies in this area, such as the proactive attitudes analysed in this study, acquires strategic relevance for both professional practice and academic research.

5. Conclusions

This study is presented in light of the changes promoted by the EU for the drastic reduction of waste, which highlights the need to expand the knowledge of academic literature regarding waste accounting processes for the CE. The results obtained in our study led to different contributions. For academics, progress is made in defining waste accounting boundaries and the environmental proactivity of auditors as a basis for research in auditing and assurance processes, specifically about circular models for closing material loops.

For the upcoming CE scenario, one of the most noteworthy contributions for accounting scholars is the empirical development of an environmental proactivity index for auditors, which integrates regulatory knowledge, practical experience, and attitudes toward sustainability assurance. This methodological proposal enables the characterization of professional auditing profiles from an environmental perspective, which is both original and valuable at academic and practical levels. To the best of our knowledge, this is the first attempt to address the definition and application of the concept of environmental proactivity among auditors, particularly in the context of waste and the CE. Both academics and practitioners can use our results as a starting point and reference to expand this research or apply benchmarking among audit professionals in these topics.

From the auditors' perspective, a contribution is also made to analyse the relevance of the measurement waste and material flows in companies. While reporting is proving to be a compelling motivation for companies to measure internal flows of materials and resources, a further step is needed in detailed waste accounting and the introduction of specific management accounting practices for waste valuation and management. These findings have implications for practitioners, auditors, accountants, and managers. The environmental proactivity of internal auditors could decrease information asymmetry related to sustainability and facilitate effective reporting between auditors and managers. Proactive auditors can use specific waste and CE-related information to advise their clients on waste accounting

practices. Specifically for audits, practitioners are provided with arguments to enhance their environmental proactivity and how it can help minimise the competitive advantage that large auditing firms have held in assuring sustainability reports in recent years.

The results may also be helpful to policymakers when defining specific requirements for internal auditing and assurance of sustainability reports, thereby enhancing the potential of auditors and their involvement in sustainability issues. Institutions could define specific training plans, and the harmonization of the European profiles of these professionals, not only in accounting audits, but also in the practices of sustainability information assurance, particularly, for accounting practices applied to waste, beyond the national borders of the member countries in the EU.

In the short and medium term, auditors can assist in the introduction of more advanced practices for waste accounting checking the specific accounting of resource and material flows, and information on their efficient use, waste reduction and recycling and recovery beyond established accounting auditing standards, and offering a more comprehensive view of the risks and opportunities of the organization in terms of environmental sustainability and the CE.

The limitations of this exploratory study are mainly associated with the qualitative method and geographic scope, which preclude generalizability. Although interviews are considered suitable for this study, the interviewed auditors are Spanish, and the results cannot be applied directly to other countries without adaptation to their institutional contexts. However, waste accounting primarily affects internal measurement, cost and management accounting, and reporting. Thus, the constraints of financial accounting regulation do not limit the application of the results to other European countries. In addition, the methodology for the proactivity index can be adapted to other geographical areas and sustainability standards. Future studies could consider obtaining a larger sample and conducting hybrid interviews in several EU countries.

Other limitations are due to potential bias related to the interviews, as the answers depend, at least partially, on the perception of the auditors being interviewed. Even if no clear indications of such bias were detected, it must be considered a limitation of the applied methodology. Nevertheless, we believe that we offer valuable insights into an unexplored topic that is characterised by its complexity and fast development. Ultimately, our analysis primarily focuses on the key institutional stakeholders. However, the results obtained in this study can be used to analyze the perspectives of accountants and other external auditors, as well as assurance or supervisory authorities.

As regulations continue to evolve towards accounting practices inherent to waste and CE that are more convergent internationally, these initial results will serve as a basis for extending them to other accounting environments and practices. Future research should explore innovative methodologies, technologies, and frameworks for integrating environmental issues into audit processes, thereby advancing theoretical understanding and practical application in this critical domain.

Author contributions

AAU, JVG, RR: methodology; SS, RR, AAU, JVG: formal analysis, review and editing; SS, AAU: conceptualization. SS, RR, AAU, JVG: original draft preparation. SS, RR, AAU, JVG: revisions.

Declaration of generative AI and AI-assisted technologies in the writing process

While preparing this work, the authors did not use AI technologies, except for the final review of the writing style through the “Grammarly” application.

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Notes

1. $\lambda > 0.83$; Cronbach's Alpha = 0.96; Average Variance Extracted (AVE) = 0.78; Composite Reliability (CR) = 0.96.

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