

Toward a definition of waste accounting in a circular economy: Evidence from auditors

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Abstract

In the European Union, many companies are introducing accounting mechanisms to circular economy models for a "zero waste" production. In this context, this study contributes to the knowledge base on circular accounting and to the definition of the emerging waste accounting discipline, which is still in development. Within the Stakeholder theoretical framework, this study frames waste accounting as the intersection of various accounting areas relevant to waste management in a circular economy and auditing processes. The auditors' perception concerning the introduction and reporting of circular processes and waste-related accounting in companies is analysed through 94 hybrid interviews conducted with auditors in Spain.

Keywords: Waste accounting, Environmental accounting, Auditors, Circular economy, Sustainability reporting.



1. Introduction

Today, waste management has become a fundamental pillar of corporate sustainability strategies, driven by increasing regulations and the need to minimise material consumption. In this context, circular accounting is emerging as a key tool for efficiently measuring, managing, and reporting resource use and waste generation, aligning with the principles of the circular economy (CE) (Aranda-Usón et al., 2022). Governments and institutions are driving the CE to transform the linear model of production into a circular one in which the flows of materials and resources are closed, maintaining the added value of products and resources for as long as possible through different stages of recycling and valorisation (Portillo-Tarragona et al., 2022). Given this growing interest in the CE for a “zero waste” scenario, the internal measurement and reporting of waste management and recycling becomes especially relevant in compliance with both the Directive (EU) 2022/2464 as Regards Corporate Sustainability Reporting, 2022, known as the CSRD Directive, as well as the EU taxonomy of sustainable investments (Regulation (EU) 2020/852 on the Establishment of a Framework to Facilitate Sustainable Investment, and Amending Regulation (EU) 2019/2088, 2020).

This scenario raises questions for scholars regarding the definition and level of introduction of waste-related accounting, as well as the role of the auditors for the effective integration of different accounting areas that involve waste measurement, registration, and reporting. Research on accounting processes for measuring and recording waste as secondary materials for closing loops in a CE model is still in an early stage of development (Aranda-Usón et al., 2024). Despite the interest in measuring and reporting waste flows according to the European Sustainability Reporting Standards (ESRS) developed by the European Financial Reporting Advisory Group (EFRAG) and published at the end of 2023 (Commission Delegated Regulation (EU) 2023/2772 as Regards Sustainability Reporting Standards, 2023), waste accounting as a specific topic in the framework of environmental accounting is understudied.

Regarding the measurement of resource flows, some authors identified the lack of standardization in accounting systems as one of the main barriers to the effective implementation of circular accounting (Amay Vicuña et al., 2020). In the coming years, it is expected that the audit processes will act as catalysts for the adoption of better accounting practices in waste management, promoting transparency and regulatory compliance (Gibassier, 2017).

The accounting aspects inherent to waste and scrap go beyond the traditional consideration of environmental aspects in accounting because they involve the measurement and recording of specific aspects of closing material loops, including collaborative aspects for waste management and recovery (Franco, 2017). A priori, waste accounting sits at the intersection of different accounting areas applicable to waste, , such as specific financial accounting rules, environmental accounting (Thottoli, 2022), and environmental management accounting (EMA) and reporting (Schaltegger & Burritt, 2017). Nevertheless, specific general rules would favor the reduction of material losses and, consequently, the more efficient use of resources, as demonstrated by the accounting of material and resource flows (Schmidt et al., 2015).

Furthermore, internal accounting practices are the fulcrum for the effective application of management accounting tools to improve cost efficiency and environmental performance optimisation in a CE (Marco-Fondevila et al., 2023), such as waste recycling and valorisation, energy efficiency and renewables (Scarpellini et al., 2021), water withdrawals, and the

reduction of CO₂ emissions (Jesse et al., 2023). In this area, material flow cost accounting (MFCA) has also proven to help quantify and monitor the impact of production and consumption in a circular context (Aranda-Usón et al., 2024). However, gaps persist in the literature regarding the definition and measurement of specific waste-related accounting practices and their intersection at the company level.

Given the increasingly fundamental role that waste-related activities play in production processes, this study reflects on the definition of waste accounting and initiates an emerging debate about its specificity as an intersection of accounting areas in a CE context. Furthermore, the role of accountants and auditors in the sustainability context continues to evolve (Lai & Stacchezzini, 2021), requiring further development of specific frameworks for auditing and valuation of waste-related items in financial accounting.

Through this study, we invite accounting scholars to contribute to the conceptualisation of waste accounting as a specific topic, rather than the more general environmental accounting framework in which it has been primarily developed. To this end, this study provides a definition of the emerging waste accounting discipline, framed as the intersection of various accounting areas relevant to waste management in a CE. Based on the proposed definition, the first phase of our study's analysis categorises waste-related accounting practices and their relevance across different accounting areas, marking one of the key contributions of this research (RQ1). Main practices are analysed from the auditors' perspective to define the extent to which companies measure waste flows for the purpose of measuring and reporting waste in a circular accounting (RQ2). Finally, due to the increasing role of auditors in sustainability reporting analysis, this study examines the extent to which auditors analyse waste accounting practices and waste flow reporting within the framework of Stakeholder theory in financial audit processes (RQ3).

2. Background

2.1 Waste accounting definition and boundaries

Accounting practices related to waste management in companies have evolved significantly in recent years due to the growing importance of sustainability in general, and the CE for waste reduction, in particular. The approaches from EMA highlight that companies record and analyse the waste-related environmental costs (Di Vaio et al., 2023). Notably, EMA facilitates the evaluation, measurement, management, and recycling of waste, as well as resource efficiency, including energy efficiency and operational cost reduction, while also promoting the development of specific waste accounting practices within companies (Llena-Macarulla et al., 2023). However, despite the relevant advances of EMA, several significant challenges remain in studying specific waste accounting practices in companies in a CE context (Etxeberria et al., 2023).

At present, waste management is constantly evolving, adapting to the demands of the CE, which seeks to optimize resources and minimise environmental impact (Aranda-Usón et al., 2020). Thus, the traditional approach to waste management accounting from the more general framework of EMA may not be sufficient to cover the most recent practices for waste, such as the incorporation of digital technologies for recycling, the real-time monitoring and analysis of recycled materials in circular systems, or greater levels of transparency and traceability in greater levels of transparency and traceability throughout waste management processes to improve corporate sustainability in the highest sense (Del Baldo & D'Anghela, 2020). As stated by

Puigvert Romia et al. (2023), the current perspective on the treatment that accounting legislation offers for waste, by-products, and environmental issues remains sparse. By reviewing documentary sources and accounting legislation, these authors confirm the poor accounting treatment afforded to waste and by-products. The analysis of the previous literature leads us to open a debate on the development of accounting practices for waste from both academic and professional perspectives.

Corrado et al. (2019) provide a list of waste accounting practices, outlining the link between policy intervention areas and the related accounting needs applicable to the food sector. These authors classify three main topics for waste accounting: waste prevention (e.g., reduction of inefficiencies); waste management (optimisation of treatments and facilities); and waste valorisation (e.g., producing biomaterials or biofuels). However, the specific research on waste accounting practices for the CE is a still-emerging topic in the accounting literature (Scarpellini et al., 2020).

From the analysis of main accounting issues applied to waste in general, we observe accounting implications across various spheres, across various spheres, such as financial accounting, management accounting, and reporting. Management accounting applied to waste stands out as the predominant topic in the waste-related accounting literature (Di Vaio et al., 2023; Seneviratne & Kalpani, 2020), recently enhanced with circular accounting (Aranda-Usón et al., 2024), and reporting waste metrics for the CE (Kuba-Khoury et al., 2025). Notably, we could consider that waste management accounting is the determining factor in the accounting aspects related to waste.

In a seminal contribution to the accounting issues related to waste, Laughlin & Varangu (1991) defined two approaches to waste management accounting practices that need to be merged: the approach affected by regulations and the market-based approach for environmental protection (Gray & Bebbington, 2000). These authors established the initial basis for waste management accounting practices within the environmental accounting scheme. In fact, numerous aspects of accounting for waste, traditionally integrated into environmental accounting, have been carried out within the framework of EMA (Wilmshurst & Frost, 2001). Some EMA features apply to solid waste accounting methods, assisting organisations in both minimising waste generation and estimating the related flows (Dowie et al., 1998).

At the beginning of the 21st, the System of Environmental Economic Accounting (SEEA) provided a list of transactions that integrates the waste management accounting, such as protection of ambient air and climate; waste water management; waste management; protection of soil and groundwater; noise and vibration abatement; protection of biodiversity and landscape; protection against radiation; research and development; and other environmental protection activities related to waste (United Nations, 2000). Subsequently, material flow accounts are drawn into the residuals produced as waste that are accounted on a materials and waste accounting basis in the SEEA-2003 framework as part of the debate around weak and strong sustainability in the SEEA (Dietz & Neumayer, 2007).

Among scholars, Qian & Burritt (2007) extend environmental accounting to waste management based on the idea that accounting for waste needs direct monetary and physical flow information. These authors analyse how environmental accounting information extends beyond the scope of conventional costs to include potentially hidden, future, and contingent costs. Thus, accounting for waste practices needs to involve also 'externalities' beyond the boundary of organisations

(Bebbington, 2001), as part of the substantive changes in the accounting processes for waste resulting from the organisational changes prompted by the environmental crisis (Larrinaga-Gonzalez & Bebbington, 2001).

The predominance of the area of waste management accounting is also evident in the importance given to environmental management tools in recent decades, which have enabled the analysis of the traceability of all incoming materials and the correct allocation of costs, both to the final product and to the waste generated. Through environmental management systems, it has been possible to classify production based on the losses generated by waste and emissions, as well as the waste management costs incurred by each cost center for waste treatment, recycling, or valorisation (Puigvert Romia & Ángel, 2023). In previous studies, waste-related accounting refers to the process of recording and valuing by-products, waste, and scraps generated during production and service processes, either as a cost or as a means of reducing revenue through internal recycling (if feasible), or as income derived from their sale. Specifically for reporting, Ha and Mansi (2023) highlight the limited research available on waste accounting and reporting.. These authors define specific indicators of waste management costs, including the financial cost of waste management and related revenues. 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 conceptualisation of waste accounting, as a more specific topic than the broader environmental accounting framework in which it has been primarily developed.

Based on these arguments, we define waste accounting (Figure 1) 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. In particular, for financial accounting, waste accounting includes provisions related to solid waste, financial risks associated with waste, fines and penalties, waste taxes, charges, fees, subsidies, and other market-based instruments, as well as recording income derived from the sale or reuse of these materials. These accounting practices also include waste generation, valorisation, by-product production, and the management of residues within the production process.valorisation

Waste management accounting integrates measurement and cost calculation, constructing the appropriate information to measure waste and performance (Latifah & Soewarno, 2023), for every category of waste material, scraps, by-products, and the analysis of specific ratios for decision-making processes, as Evangelinos & Nikolaou (2011) proposed for eco-efficiency applied to the solid waste management.

Figure 1. Synopsis of waste accounting definition.



For waste accounting, it is essential to examine the accounting treatment provided by national regulations, international accounting and financial reporting standards (IAS and IFRS), and management accounting for the costs associated with waste generation and the production of by-products during the production process. The recording, valuation, and impact of other waste-related costs on companies' results will also be taken into account.

Based on the proposed definition of waste accounting and its conceptualisation, a specific analytical framework is needed that can effectively reflect the multifaceted nature of various accounting practices applicable to waste in its broadest sense. Since this is a new topic in literature, an initial question arises to define the main waste-related accounting practices and their relevance across different accounting areas (RQ1) as one of the contributions of this research: RQ1) What are the specific waste accounting practices, and what is their relevance in audited companies?

2.2 Measurement and waste accounting for a circular economy

Combining the principles of CE with material flow and waste accounting could allow the optimisation of operating costs and the promotion of innovative and more sustainable accounting models (Aranda-Usón et al., 2024). However, its implementation requires the standardization of metrics and faces some resistance to change within organisations.



Accounting, traditionally focused on financial flows, is facing the need to evolve to incorporate the measurement, monitoring, and valuation of material and energy flows, as well as the environmental and social impact associated with waste generation and management for the CE (Scarpellini, 2021). Recent research explores various methodologies, indicators, and conceptual frameworks to adapt accounting practices to this new circular scenario, seeking to provide relevant information for business decision-making and public policies aimed at the CE (Arjaliès et al., 2023; Etxeberria et al., 2023).

Taken together, the studies to date highlight the need to develop more specific waste accounting tools for material and waste flows within the framework of the CE and the waste management regulation in the EU (Agovino et al., 2024). Some authors explored information disclosure with a circular approach (Gunarathne et al., 2021; Marco-Fondevila et al., 2021). Álvarez-Etxeberria et al. (2023) analysed how Spanish companies responded to the EU sustainability regulations for disclosure. Through a survey of 120 companies, these authors demonstrate that the adoption of certain practices is driven not only by regulatory coercion but also by mimetic and normative processes. These studies suggest that, also for the CE, the effectiveness of regulation depends not only on its mandatory nature but also on its specificity and the context of prior disclosure. However, despite progress, the effective implementation of standards that more accurately reflect the CE by companies is still understudied in the literature.

Research ranges from quantitative indicators based on physical flows (Barros et al., 2023), to comprehensive frameworks that consider multiple dimensions (Sánchez-Ortiz et al., 2020), and a critical analysis of indicators at the product level (Jerome et al., 2022). However, a gap is identified in the development of robust internal indicators to dimension the introduction of the CE in companies (Kristensen & Mosgaard, 2020) and the need to address the integration of CE-related internal measurement into EMA practices. There is a consensus on the need to overcome the limitations of conventional general accepted accounting principles (GAAP) by adopting more holistic approaches, such as three-dimensional accounting (Ceballos Rincón et al., 2016), and integrating the CE principles. Although approaches such as MFCA can balance the waste and resource flows, significant technical difficulties remain in data aggregation and accounting coverage in many companies. These data issues for waste (availability, quality, and comparability) are a recurring obstacle mentioned implicitly or explicitly in several studies on the subject (Di Vaio et al., 2023).

The need for a more specific waste accounting approach in a circular context highlights the limitations of purely financial metrics in capturing the full value (and cost) for waste management, measurement, and reporting in circular accounting.

Given these considerations, a second research question is posed to define and analyse the extent to which companies measure waste flows for the purpose of measuring and reporting waste in a circular accounting framework from the perspective of auditors: RQ2) To what extent do audited companies measure and report waste flows in a circular framework?

2.3 Stakeholders and waste accounting in auditing processes

This study is approached from the auditors' perspective of waste accounting practices and the stakeholders' pressure, a topic that has been practically uncovered in the accounting literature. In this context, the Stakeholder theory (Freeman, 1984) is considered adequate to analyse the pressure perceived by companies when disclosing the CE (Kuba-Khoury et al., 2025). As

stated by Salvia et al. (2021), waste management is a wicked problem characterized by complex social dynamics and stakeholders. Thus, the stakeholders could influence waste accounting and auditing processes.

In the European context, Moneva et al. (2023) emphasize the pivotal role of institutional stakeholders, with clients, national and regional administrations, and partners or shareholders being the most significant actors in promoting firms' adoption of sustainability principles and the CE. Furthermore, within the general framework of Stakeholder theory, Benito-Bentué et al. (2022) analyse how financial institutions respond to stakeholders' pressure in the application of the EU Sustainable Finance Taxonomy (Regulation (EU) 2020/852), focusing on promoting environmental change within the context of sustainability reporting and the CE.

For waste accounting, some studies focused on the adoption and development of EMA practices, Nguyen (2024) demonstrates that regulatory pressure, combined with stakeholder pressure, firm size, and perceived benefits, significantly influences EMA adoption. Kuba-Khoury et al. (2025) offer one of the few studies focused on circular accountability in the waste sector to identify national and regional administrations as key stakeholders in the process. The literature demonstrates that stakeholder pressure plays a significant role in driving the adoption of circular accounting. The ability to align strategic objectives with stakeholder engagement is a key challenge for companies that decide to implement circular business models (Salvioni & Almici, 2020). However, specifically for waste accounting, stakeholder analysis is an incipient topic.

Thus, the role of auditing in waste management behaviour and the adaptation of auditing to CE environments (Saeed et al., 2024) emerge as a key mechanism to assess and potentially influence the environmental performance of organisations (Gallardo-Vazquez et al., 2024). Auditors, in turn influenced by stakeholders in the face of CE, can affect the adoption of more advanced waste accounting practices, with the corresponding measurement and reporting within the framework of sustainability. Similarly, to what has been demonstrated regarding the influence of stakeholders on the use of environmental audits (Darnall et al., 2009). However, research on this topic remains scarce. To fill this gap, it is crucial to understand the extent to which auditors analyse waste accounting practices in financial, and non-financial audit processes, and their perception of the stakeholders' pressure promoting the CE and waste measurement. This leads to a third unpublished research question for this study: RQ3) What is the auditors' perception of the pressure from stakeholders for analyzing waste measurement and reporting in auditing processes?

3. Methodology

To achieve this study's objectives, a specific methodology was developed through 94 hybrid interviews with auditors in Spain, of which almost 33% are women. The hybrid method included both open-ended and mixed-choice questions, as well as Likert-scale questions, to gather the authors' opinions on the accounting practices of companies related to waste and the closing of material flow loops for a CE. Responses mainly were collected between the last four months of 2024 and the first semester of 2025, in person or online in most cases. Questions were validated by a panel of four experts (from the auditors' association and academia) and pilot-tested with the two auditors. After incorporating their feedback, some minor adjustments were introduced to phrasing and terminology.

The interviewees were selected quasi-randomly as the interviews were conducted with participants in courses for auditors, which auditors typically attend annually to update their training. In some cases, specialized forums and other meetings were also used. It should be noted that recruiting auditors for this type of study is not straightforward. To minimise the length of the collection of open-ended questions, the Likert-scale questions were provided to them in advance, which were compiled along with the open-ended responses, which were subsequently transcribed. Therefore, it was decided to conduct this type of hybrid interview, with an average response time of approximately half an hour, which allows for a shorter response time and the parallel collection of perception data using a Likert scale. A potential source of bias in the interviews is that the answers depend partly on the perceptions of the auditors interviewed.. Even if no clear indications of such bias were detected because the training courses through which they were contacted have general contents and no specific relation with the study objective, it must be considered a limitation of the applied methodology.

Based on data from the 2024 report on the state of auditing in Spain, published by the Spanish Government's Institute of Accounting and Auditing (ICAC, 2024), the sample represents 2.36% of the 3573 practicing auditors registered in the National Official Register of Auditors. The number of obtained answers is considered sufficient for this qualitative analysis, as it represents a sample of interviews that yields a high number of responses to open-ended questions. The interviewees are from the private sector, and the percentage of auditors in the sample core age groups is close to the total number of auditors, being approximately 26% between 40 and 50 years old, and approximately 30% between 51 and 60 years old. To minimise selection and social desirability bias, early and late respondents were compared, and no significant differences were observed between the two groups.

Table 1 describes the questions related to RQ1, which aim to analyse specific waste accounting practices summarised in Figure 1, and their relevance in audited companies. To this end, eight accounting practices are selected based on the previous literature (Aranda-Usón et al., 2024; Kuba-Khoury et al., 2025; Llena-Macarulla et al., 2023) and grouped into the two spheres, internal and external, of waste accounting: waste financial accounting [wF] and waste management accounting [wM].

Table 1. Variables to gather auditors' opinions on the relevance of accounting practices related to waste

RQ1	COD.	Description	Type
wF	EXPINV	Classification of environmental expenses and investments (subaccounts)	Likert scale from 0 to 10 (Zero = not relevant; 10 = totally relevant; N.A. = Not
	VALMAT	Classification and specific valuation of recycled and/or recovered materials	
	VALWAST	Specific classification and assessment of waste for recycling	
wM	ACCOUNT	Accounting department plays a leading role in collecting data on sustainability and waste	N.A. = Not
	LCA	Implementation of life cycle assessment (LCA) tools (applied to waste)	

	SHAR	Calculation of specific costs of participation in collaborative “ sharing ” models for waste	available)
	MFCA	Implementation of UNE-EN ISO 14051 for material flows	
	FOOTPR	Measuring carbon footprint or similar	
	Other	Other accounting practices related to waste	Open question

For the second analysis (RQ2), the following questions are posed in order to define the level of measurement and reporting of audited companies' waste flows (Table 2). To achieve this goal, the auditors' perspective is obtained through a Likert scale assigned to 6 variables designed explicitly for this study and based on the ESRS related to waste flow measurement. This section of the hybrid interview is related to the reporting for waste as part of the waste accounting definition (Waste reporting: wR).

Table 2. Variables to gather auditors' opinions on the measurement of waste and resource flows for closing the material loops in companies

RQ2	COD.	Description	Type
wR	CHAIN	Actions for sustainability in the value chain	Likert scale from 0 to 10 (Zero = not relevant; 10 = totally relevant; N.A. = Not available)
	FLOIN	Resource inflows	
	FLOUT	Resource outflows	
	WAST	Waste and emissions	
	VALOR	Strategy for resource valorisation	
	RES	Energy flows and renewable energies or green electricity	
TIMEINF	Opinion about the timeframe in which companies will measure and report more on sustainability and waste in the future? Under what scenario? How could they be incentivized?		Open question

To approach the second topic of research (RQ3), Table 3 shows the variables designed to gather the auditors' perception regarding the stakeholders' influence in analyzing the measurement and reporting of waste and EC issues in companies.

Table 3. Variables to gather auditors' perception regarding the stakeholders' pressure

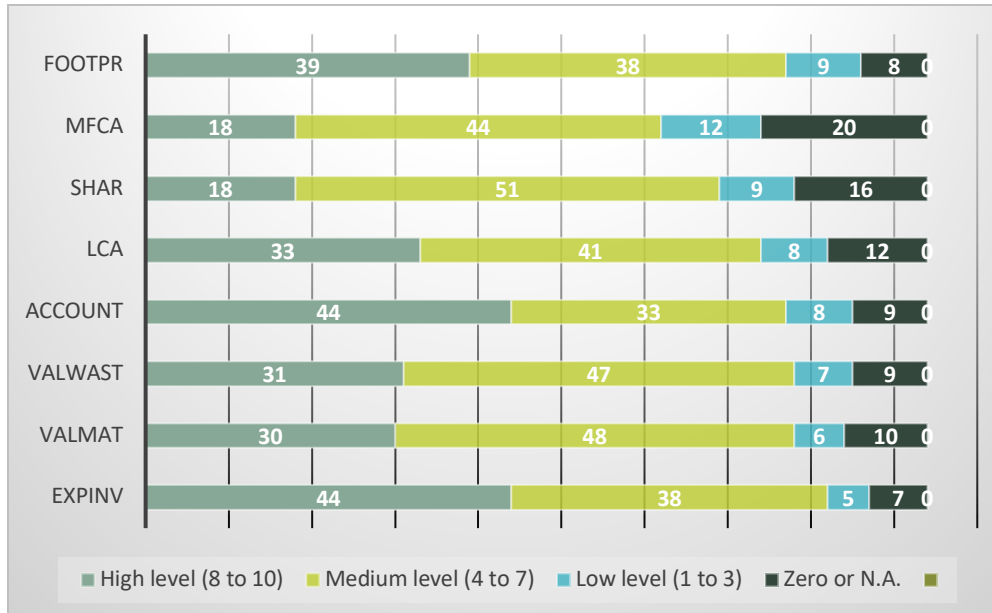
RQ3	COD.	Description	Type
Main stakehold.	PresEU	EU pressure	(Zero = not relevant; 10 = totally relevant; N.A. = Not available)
	PresESP	National/regional administrations pressure	
	PresCLI	Clients pressure	
	PresICAC	Accounting&Account Audits, Spanish institutes pressure	
	PresSTAN	Pressure received through International. Standards	

The data collected are analysed using qualitative methodologies, including spreadsheets, cross-pivot tables for Likert scale variables, and relational text analysis. In particular, we conducted a qualitative study of open-ended questions, classifying and aggregating the answers obtained, which were transcribed into a text format. As the first stage of analysis, recurring segments in the answers were identified and categorised, and a terms count was conducted by the team members. Subsequently, the obtained answers were coded and analysed to achieve the main results derived from the recurring themes within the answers. We ensure inter-coder reliability by employing multiple coders to analyse similar contents in open questions. To limit subjectivity and to assure the codification validity the contents were coded for all the team's members and the coding results were coded by the members separately and then unified for closeness categories. The reliability of the content analysis was checked through criteria of stability, reproducibility and accuracy.

4. Main Results

As a first result of this study (RQ1), the relevance of waste accounting practices was analysed in a CE context (Figure 2). It can be observed that the most significant relevance is given to the classification of environmental expenses and investments (subaccounts) [EXPINV] with the highest number of responses in high and medium scores, followed by the activity of the accounting department in the area of sustainability [ACCOUNT] and the measurement of the carbon footprint or similar [FOOTPR]. Currently, the implementation of UNE-EN ISO 14051 and cost accounting tools for material flows [MFCA] is considered the least relevant for companies, with a level minimally above the calculation of specific costs of participation in collaborative "sharing" models [SHAR].

Figure 2. Level of relevance assigned by auditors to main waste accounting practices (Likert scores from 0 [no relevance] to 10 [very high relevance] classified into four levels of relevance: Low: ≤ 4 ; Medium: $+4$ to <8 ; High: ≥ 8)



These results indicate that waste-related accounting practices in companies are considered of interest, but with a moderate level of relevance. The most developed practices are those inherent to costs and, therefore, more closely related to value generation. The results obtained through the open question related to RQ1 indicate that auditors perceive that companies mostly comply with basic monitoring of physical waste generation and its direct costs, likely driven by the regulation and control of basic expenses. However, more advanced accounting practices such as internal cost allocation, the valuation of cost savings, and the strategic use of this information for decision-making appear to be much less widespread, indicating a limited maturity of waste management accounting geared toward optimisation and circularity.

Regarding the second analysis question (RQ2), the results obtained allow classifying the measurements of waste and resource flows for the material loops closing and the relevance of the related accounting records in companies based on the level of experience of the auditors (Table 4).

Table 4. Level of implementation of the measurement of waste and resource flows for their accounting treatment in companies (Likert scores from 0 to 10 and classified according to the professional experience of the auditors).

Years of experience as Auditors	CHAIN Average	FLOIN Average	FLOUT Average	WAST Average	VALOR Average	RES Average	Total answers
Between 10 and 20	2.35	2.46	2.42	3.77	2.85	3.35	26
Between 21 and 30	2.90	3.04	3.04	3.71	2.86	2.85	29
More than 30	2.74	2.65	2.69	4.11	3.33	3.19	28

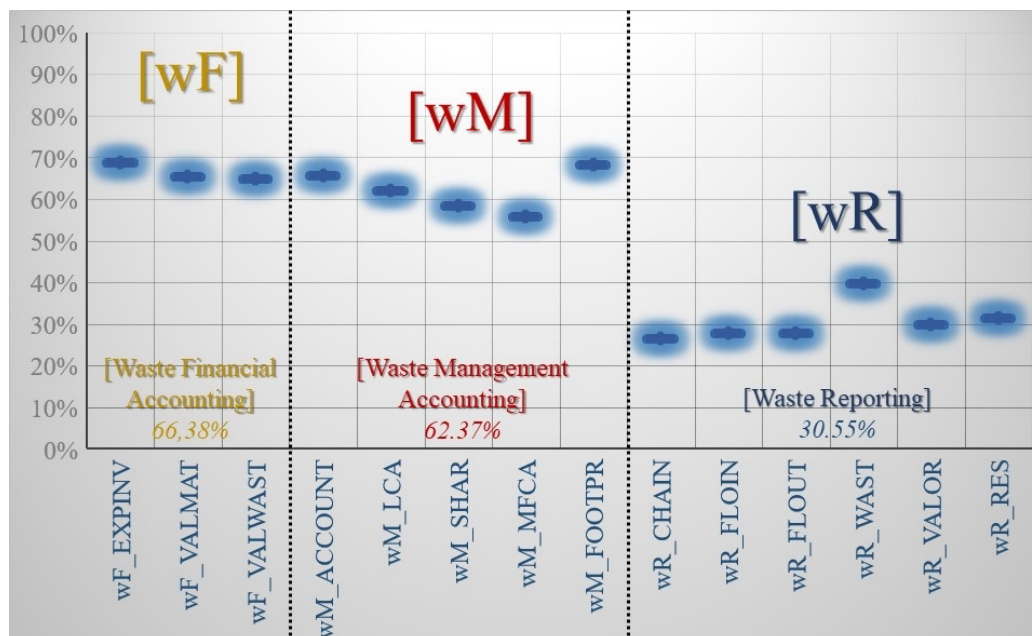
Less than 10	2.38	3.38	3.00	5.00	2.50	3.00	9
N.A.							2
	CHAIN	FLOIN	FLOUT	WAST	VALOR	RES	
Average total	2.6	2.8	2.8	4.0	3.0	3.1	
MODE	● 1	● 2	● 2	● 3	● 0	● 1	

Auditors' perceptions of the measurement of key resource flows for circular accounting reveal generally low to very low scores for all measurements, except for the more general indicators for waste and emissions [WAST], which is considered the most widespread and has the highest scores, especially among younger auditors.

The value chain indicators [CHAIN] are considered less viable with an average score of no more than 3 points. Similar results are obtained for resource valorisation [VALUE], with a mode of zero points on the Likert scale. In general, no significant differences are observed in the responses obtained based on the auditors' professional experience.

To conduct an integrated analysis of the three areas of waste accounting (RQ1 and RQ2), the average scores awarded by auditors to accounting practices, financial accounting (wF), and management accounting (wM), and the measurement of waste flows and resources for reporting (wR) were obtained. Figure 3 summarizes the total percentages obtained for each of the three areas analysed (on a 10-point Likert scale) and shows that wF practices are considered the most relevant, followed by wM practices.

Figure 3. Percentage awarded by auditors to the three accounting areas.



It should be noted that these are not separate areas, as reporting is integrated mainly into management accounting, which in turn overlaps with financial accounting (Figure 1). A closer look at the responses obtained for the three areas (Table 5) reveals no significant differences based on the auditors' age or the number of audits they perform per year. The only notable difference is that auditors who conduct a higher number of audits assign greater importance to responses in the wF category. Furthermore, auditors who perform a lower total number of audits, as well as younger auditors, tend to assign slightly lower scores.

Table 5. Auditors' opinions, categorised by level, for three areas of waste accounting, according to their age and the number of audits per year.

	Waste financial accounting			Waste managem. accounting			Waste reporting		
	wF	wF	wF	wM	wM	wM	wR	wR	wR
	High	Medium	Low	High	Medium	Low	High	Medium	Low
Aud. high (≥ 30)	15	5	5	5	12	7	2	2	20
Aud. medium (11-30)	10	14	5	5	16	7		7	22
Aud. low (≤ 10)	6	18	6	9	18			10	21
Age <40	8	4	5	3	8	6	0	4	13
Age 40-60	19	22	10	14	26	10	2	13	36
Age >60	4	17	2	3	17	2	0	3	19

Average scores of waste accounting through the Likert scale over 10: (low: ≤ 4 ; medium: 5-7; high ≥ 8 - N.A. are not considered)

The analysis is supplemented by an open question regarding the auditors' opinion on the timeframe in which companies will measure and report more on sustainability and waste, as well as how disclosure could be incentivized. The interviewees noted that most companies typically report only under the regulatory scheme and mandatory standards. Specific incentives would increase the level of reported information, particularly in small and medium companies, and the sustainability measurement will increase if it has a positive impact on performance. Some auditors highlight the stakeholders' pressure as a driver for waste reporting (Table 6). No significant differences were observed in the percentage of responses between male and female auditors.

Table 6. Auditors' opinions, categorised by recurring segments in the answers, regarding the timeframe in which companies will measure and report more information on sustainability and waste.

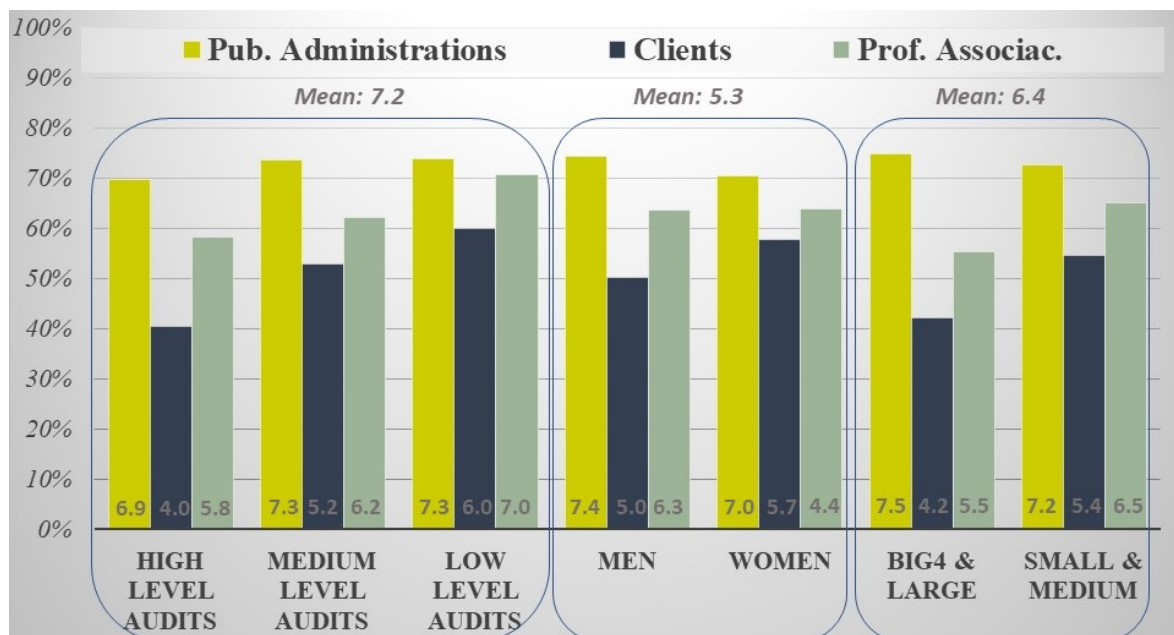
TIMEINF TEXT CODE		% TOT. Term count	% Men	% Women
If mandatory	MAND_time	43.18%	46.43%	37.50%
With incentives	INCEN_time	18.18%	17.86%	18.75%
To improve performance	PERF_time	11.36%	10.71%	12.50%

Stakeholders' pressure	STAKE_time	9.09%	10.71%	6.25%
Simplified procedures	COST_time	9.09%	10.71%	6.25%
Required in the value chain	CHAI_time	4.55%	0.00%	12.50%
Other	OTH_time	4.55%	3.57%	6.25%

From the open question, it is observed that the auditors perceive a potential role for themselves in waste accounting and the measurement and assurance of the CE, although they also identify significant barriers related to current demand, skills, and standards. The need for waste accounting and CE reporting standards is also highlighted. The potential for auditors to promote best practices in waste accounting and CE is pointed out. However, these professionals perceive a low current demand for specific assurance services in this field from companies, which is identified as a significant barrier.

As the third phase of analysis (RQ3), Figure 4 summarizes the auditors' perceptions of pressure from different stakeholders, categorised by their profiles.

Figure 4. Auditors' perception of the pressure from stakeholders, classified according to their profiles.



Stakeholders have been grouped into three categories to differentiate between public administrations, clients, professional, sectoral associations, and standards-setting entities. It is observed that auditors with a lower volume of audits (and who, consequently, in some cases audit larger companies) perceive greater pressure from stakeholders, particularly from clients. The auditor's gender indicates that women also perceive greater pressure from clients, while men perceive greater pressure from public administrations. A similar trend is observed when the size of their audit firm differentiates auditors.

4.1 Discussion

The conceptualisation of waste accounting within a CE framework has received limited prior attention conceptualisation (RQ1) with the level of specificity and scope applied in this study, making it difficult to discuss the results. However, some arguments for reflection linked to previous studies may be framed for discussion. Firstly, it could be considered whether accounting practices related to waste management are sufficiently integrated within the framework of environmental accounting (Qian & Burritt, 2007) or whether they warrant their own research topic, even within the umbrella of the EMA (Di Vaio et al., 2023), where they have been developing. In this study, we believe we have contributed sufficient arguments to support this second position.

Although it is undeniable that various accounting operations related to waste fall under environmental accounting, it seems inevitable that a research topic in accounting must be dedicated exclusively to waste and the corresponding accounting effects that it entails in a zero-waste scenario. Recycling involves physical and monetary information associated with waste flows and activities, as well as potential adverse environmental impacts, the transportation of recovered materials, and direct, indirect, and hidden costs for waste management. Thus, a specific area of analysis must be devoted to defining and conceptualising waste accounting, based on the concepts and features of environmental accounting, and considering the impact of waste management on accounting for monetary and physical flows in waste streams and activities.

Waste accounting has a multifaceted construct rather than a unidimensional form, as it was proposed for defining environmental accounting (Qian & Burritt, 2007). It cannot be overlooked that waste accounting also includes the hidden environmental costs of waste, and accounting for the external environmental impacts of waste streams (Qian et al., 2011). In addition, waste management has been enhanced with relevant social impacts in a circular scheme (Scarpellini, 2022), that brings measurement and accounting for waste closer to sustainability accounting (D'Amore et al., 2025) and circular sustainability accounting (Aranda-Usón et al., 2022). Thus, the empirical contribution of this study lies in its identification of the interrelation between waste accounting and various accounting areas, including waste management as a mediating link between environmental accounting strategy and sustainability performance, as demonstrated by Latifah & Soewarno (2023).

Notably, the need for measurement in reporting on material and waste flows (RQ2) (Adler et al., 2022) marked a new era for waste management accounting, indicating an increasing intersection with financial accounting, and with financial and non-financial reporting as a trend inherent to waste management. In addition, the CE places considerable importance on waste and by-products, highlighting 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). Their proper recording and accounting treatment become essential for adequate management of waste and materials flows by the company (Puigvert-Romia et al., 2022).

The definition and measurement of waste flows (RQ2) lead us to reflect on the application of materiality to sustainability information. We infer on how financial and non-financial audit processes can interact to achieve broader assurance objectives within the sustainability framework, where waste is one of the relevant environmental impacts. In line with Christensen et al. (2021) for corporate social responsibility, it could be argued that auditors apply tighter materiality thresholds for financial statements than for sustainability reporting. Nevertheless, barriers are identified by auditors as limitations to the interaction

between auditors and the sustainability sphere of audited companies, typically excluding information that is not strictly required in financial auditing processes.

The pattern observed in the data is evident in the low values obtained for most variables, which are low in many cases (0–3 on a 0–10 scale) These still moderate levels indicate limited implementation of waste accounting practices., which might be reluctant to change in line with Halari and Baric (2023). The issue identified by Evangelinos & Nikolaou (2011) that waste accounting methods were primarily based on self-determined accounting principles and give differentiated information is being addressed through European and international standards, which are being gradually implemented in large companies. It is here that the role of auditors becomes relevant, both in financial and non-financial information, specifically related to waste in a broad sense in line with Alajeli and Wahhab (2022).

These findings align with those reported in the academic literature, which notes a practical introduction of circular accounting practices (Aranda-Usón et al., 2024; Kuba-Khoury et al., 2025; Llana-Macarulla et al., 2023), with an increasing relevant participation of the accounting departments that are developing their own capabilities for EC and waste-related accounting practices (Scarpellini et al., 2020). However, the effective integration of waste accounting must overcome the barriers identified by the auditors, such as heterogeneous indicators, and subjectivity in impact assessment (Garst et al., 2022).

Finally, the pressure exerted by stakeholders on auditors (RQ3) confirm the results obtained by Lai & Stacchezzini (2021) on the need for expertise for the accounting and reporting department. Thus, the role played by main stakeholders, such as specific institutional agents, consulting firms, or sustainability rating agencies, in disseminating, translating, and institutionalizing the new standards is of particular interest. We confirm the evidence that firms respond to stakeholders' demand for nonfinancial information (Dal Maso et al., 2020), also from the auditors' perspective on waste and the CE. Thus, we contribute to the ongoing debate on the role of stakeholders in circular accounting (Gallardo-Vázquez et al., 2024), being consistent with other authors for reporting activities (Kuba-Khoury et al., 2025). These approaches have been enhanced by our study to waste accounting and auditing.

5. Conclusions

Within the Stakeholder theoretical framework, this study expands knowledge regarding waste accounting processes in a CE framework, a topic that remains underexplored in the accounting literature and is of increasing interest to practitioners, scholars, and policymakers. As an original approach, the intersection of different accounting areas applicable to waste management is defined from the auditors' perception. This study highlights how the transition to specific waste accounting practices within a CE framework requires companies to account for all resource flows, thereby facilitating the maintenance of these resources at their maximum value and utility for as long as possible.

The definition of waste accounting provided in this study aims to initiate a debate about the specificity of accounting practices for waste, contributing to the conceptualisation of waste accounting as a distinct topic rather than the more general environmental accounting framework in which it has been primarily developed. For academics, this study advances the definition of waste accounting processes in response to the introduction of CE principles. It contributes to the emerging debate



about the specificity of waste accounting within a circular framework filling the gap in the literature regarding the definition and measurement of specific waste-related accounting practices and their intersection at the company level. As a novelty, this paper defines auditor–stakeholder interaction regarding auditing practices for sustainability and waste measurement and reporting and the influence of stakeholders.

Based on the study results, we aim to bridge the gap between academic inquiry and practical solutions for auditors. The aim is to enable these key agents to deepen their role in introducing specific GAAP for waste, applying advanced waste management accounting systems to measure and control, thereby strengthening their alignment with international standards and stakeholders. For practitioners, our findings suggest that although auditors highlight barriers for the effective analysis of waste and material flows outside the scope of financial auditing, the introduction of higher requirements for sustainability and standardising measurement methodologies will improve the quality of available information, optimizing internal coordination, and anticipating possible regulatory changes related to waste accounting. For waste accounting, auditors can promote gradual change in financial and non-financial information relevant to solid waste management, such as specific information in balance sheets, profit and loss statements, and footnotes. Thus, for policymakers, this study highlights the phase of uncertainty in which the EU financial accounting rules applicable to waste needs to be completed and harmonized, because the applied content has not been fully determined. The role of auditors in the sustainability context evolves, requiring further development of specific guidelines for auditing waste management and the circular measurement and valuation for financial accounting in response to main stakeholders.

The results of this study should be interpreted with caution due to some limitations, including the limited number of interviews collected and its restricted geographic scope within Spain. However, the quality, breadth, and novelty of the variables used allow for interesting contributions. Another potential limitation arises from the non-anonymous nature of the hybrid interview, which may have introduced a degree of social desirability bias or eventual inter-coder reliability, particularly regarding the perception of auditors with regard sustainability issues, with some auditors potentially overstating their actual engagement. Although no clear indications of such bias were detected, it cannot be completely ruled out.

Future studies could be conducted using larger samples and from other EU countries, and the findings could be compared across different auditor characteristics, such as industry specialization or client portfolio composition. Furthermore, the results obtained in this study could be used to analyse the perspective of accountants outside the audit process or supervisory authorities, as well as those of the companies themselves, through case studies. The implementation of longitudinal designs is also considered relevant, as they allow for tracking the evolution of measurement and control waste accounting practices over time.

6. Conflict of Interest

No conflicts of interest are declared.

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