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Digitalization, ESG Reporting, and Circular Economy: Accounting Challenges for Women-Led SMEs

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Abstract

This study examines how digitalization can reduce the cost and complexity of ESG and circular economy reporting for women-led SMEs within the evolving EU sustainability reporting framework, with a focus on the Danube Region. Using a conceptual accounting approach grounded in EU regulatory documents, academic literature, and prior bibliometric research, it identifies four key challenge do-mains: measurement, valuation, disclosure, and professional judgment. The analysis is complemented by an exploratory empirical extension based on publicly available documents and illustrative cases of women-led SMEs from the Danube Region. It develops an accounting-oriented problem matrix linking these challenges to digital enablers such as data platforms, automation tools, and traceability technologies. The findings suggest that digitalization improves not only efficiency, but also the reliability, auditability, comparability, and scalability of ESG reporting. A conceptual framework is proposed, connecting regulatory drivers, digital accounting capabilities, and reporting outcomes, including improved assurance readiness and access to finance. The paper also provides practical recommendations, including minimum viable ESG datasets and a staged digital adoption approach, alongside policy implications related to harmonized data requests and targeted capacity-building for SMEs. The study contributes by integrating ESG reporting, circular economy, digitalization, and gender-sensitive SME constraints into an explicitly accounting-centered analytical framework.

Keywords: circular economy; ESG reporting; CSRD; ESRS; digitalization; sustainability accounting; women-led SMEs

1. Introduction

The reform of EU sustainability reporting has significantly expanded the role of non-financial information in corporate accountability, transparency, and decision-making. At the center of this transformation stands the Corporate Sustainability Reporting Directive (CSRD), which broadens the scope of reporting entities, strengthens assurance expectations, and reinforces the digital usability of sustainability disclosures within the management report. Within this evolving framework, digitalization is embedded in the regulatory logic itself, as sustainability information is expected to become more findable, comparable, and machine-readable through standardized electronic formats and taxonomy-based mark-up. These developments affect not only large undertakings directly subject to mandatory reporting, but also smaller firms that increasingly face sustainability-related data requests from customers, lenders, investors, and public authorities [1,2]. Alongside CSRD and ESRS, the broader EU sustainable finance architecture, including the Taxonomy Regulation, further reinforces the strategic importance of sustainability-related information [5].

This indirect extension of reporting pressures to SMEs is particularly relevant in the context of the circular economy transition. Although many SMEs remain outside the formal scope of mandatory

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ESRS-based reporting, they are progressively drawn into sustainability data provision through value-chain relations and market expectations [3,4,13,14]. This "cascade effect" creates a practical challenge: smaller firms are expected to generate decision-useful ESG and circular economy information without the internal systems, professional resources, or digital infrastructure typically available to larger companies [8]. The problem is further intensified for women-led SMEs, which often operate under additional structural constraints related to access to finance, digital skills, business networks, and participation in innovation-intensive sectors [26–28].

This article is positioned within a broader regional initiative aimed at strengthening the digital and industrial capacity of women entrepreneurs for sustainable circular transition in the Danube Region. It is informed by the WE.Circular project, an Interreg Danube Region Programme initiative (2024–2026), which identifies key barriers such as digital capability gaps, underrepresentation of women in entrepreneurship and selected circular economy activities, and fragmented policy support. These challenges are particularly pronounced in the Danube macro-region, which includes 14 countries with diverse institutional conditions and uneven levels of digital and reporting maturity. In this context, scalable and low-burden approaches to ESG and circular reporting are essential [6,7].

The existing research field provides valuable but still fragmented insights. Prior studies have examined the increasing complexity of sustainability reporting regulation, the implementation burden for SMEs, and the role of digital tools in improving data collection, traceability, and reporting efficiency [10–16]. At the same time, research on digital enablers of the circular economy has expanded rapidly, while gender-explicit perspectives remain limited [9,26–28]. Bibliometric evidence indicates that women entrepreneurship appears only sporadically within the digital circular economy literature, revealing a gap between policy priorities and academic visibility [9]. This gap is significant, as it obscures how gendered structural conditions influence the feasibility of ESG and circular reporting adoption among SMEs.

The literature also reveals several points of tension. Digitalization is often presented as a solution capable of reducing reporting costs and improving data quality and assurance readiness [10,12,15]. However, emerging research emphasizes that digital tools do not automatically simplify reporting unless firms possess the accounting capabilities and professional judgment required to transform data into reliable and decision-useful disclosures [10,12,24,25]. A further tension concerns the balance between standardization and proportionality: while harmonized reporting formats enhance comparability, they may impose disproportionate burdens on SMEs unless supported by simplification frameworks, training, and appropriate infrastructure [3,4,13,14,29]. These tensions are particularly relevant for women-led SMEs, for whom sustainability reporting may represent both an opportunity for strategic visibility and an additional compliance burden.

Against this background, the present study asks: what are the core accounting challenges that women-led SMEs face in operationalizing ESG and circular economy reporting in the CSRD/ESRS environment, and how can digitalization reduce reporting burden while improving data quality and assurance readiness? To address this question, the paper develops a conceptual accounting framework at the intersection of EU sustainability regulation, SME reporting practice, circular economy disclosure requirements, and digital enablement.

The study develops a conceptual accounting framework supported by an exploratory public-data illustration to explain how sustainability reporting pressures translate into four core accounting challenge domains—measurement, valuation, disclosure, and professional judgment—for women-led SMEs. Building on this structure, the framework serves three interrelated purposes: to advance conceptual understanding within the accounting literature on SME sustainability reporting, to provide a practitioner-oriented model for staged digital adoption, and to inform policy discussions on proportional support mechanisms in regional SME contexts.

The paper argues that digitalization should be understood not simply as a compliance technology, but as an accounting enabler that supports more reliable measurement routines, stronger audit trails, greater reporting comparability, and more accessible ESG and circular economy disclosures for resource-constrained firms. The principal conclusion is that women-led SMEs can

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benefit from staged, low-burden digital reporting approaches when these are aligned with simplified data requirements, targeted training, and coherent policy support.

The study makes a threefold contribution. First, it reframes ESG and circular economy reporting in women-led SMEs as an accounting issue rather than a purely regulatory or technological one, organizing the analysis around four interrelated domains: measurement, valuation, disclosure, and professional judgment. Second, it integrates strands often treated separately in the literature—SME sustainability reporting, circular economy disclosure, gender-sensitive constraints, and digital accounting opportunities—within a single analytical framework. Third, it develops a conceptual and practice-oriented model that supports interpretation, implementation planning, and future empirical testing in regional SME support contexts. The originality of the article lies in structuring the intersection of ESG reporting, circular economy, digitalization, and women-led SMEs through an explicitly accounting-centered analytical logic.

2. Literature Review

The transformation of corporate reporting in the European Union is strongly driven by the introduction of the Corporate Sustainability Reporting Directive (CSRD) and the European Sustainability Reporting Standards (ESRS), which significantly extend the scope, depth, and assurance of sustainability disclosures. The CSRD amends the EU accounting framework by embedding sustainability reporting within the management report, supported by assurance requirements and digital reporting infrastructure. The reporting timeline is phased, beginning with large public-interest entities and extending to other large undertakings and listed SMEs, the latter entering the scope for financial years starting on or after 1 January 2026. ESRS Set 1 further operationalizes this framework, including ESRS E5 on resource use and circular economy, which introduces circularity-related metrics and reinforces the principle of double materiality [1,2].

Recognizing the disproportionate burden that such requirements may impose on smaller firms, European policy has increasingly emphasized SME-oriented simplification mechanisms. The European Financial Reporting Advisory Group (EFRAG) has developed the Voluntary Sustainability Reporting Standard for SMEs (VSME), while EU institutions promote harmonized sustainability data requests across value chains. This approach is particularly relevant in the context of women-led SMEs, which are often more vulnerable to fragmented reporting demands and limited administrative capacity [3,4,13,14,26–28].

Within circular economy accounting, a key challenge lies in translating broad conceptual frameworks into measurable and reportable indicators. The literature highlights that the circular economy lacks a single operational definition, encompassing diverse strategies such as reuse, recycling, and resource efficiency, which complicates measurement and comparability. Accounting systems must therefore capture both physical resource flows and financial implications across extended value chains, often requiring explicit boundary-setting decisions and methodological assumptions. Environmental management accounting tools, such as material flow cost accounting (MFCA), have been proposed as mechanisms to bridge physical and monetary data, supporting both decision-making and reporting [19–22,24].

Digitalization emerges as a critical enabler in this context, particularly in relation to data collection, processing, and reporting. The CSRD explicitly mandates digital reporting formats and taxonomy-based tagging, reinforcing the integration of digital tools into sustainability reporting processes. Existing literature associates digital transformation with improved data availability, automation, and traceability, which can enhance the reliability and auditability of ESG disclosures. At the same time, studies emphasize that digitalization requires complementary organizational capabilities, including accounting expertise and professional judgment, to ensure meaningful interpretation and disclosure of sustainability data [1,2,10,12,15,25].

Despite the growing body of research on digital circular economy transitions, gender perspectives remain underexplored. Recent bibliometric evidence indicates that women entrepreneurship is only marginally represented in the digital circular economy literature, suggesting

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a gap between policy priorities and academic research. Broader studies on gender and entrepreneurship demonstrate that structural factors—such as access to finance, networks, and digital skills—shape the capacity of women-led firms to engage in sustainability transitions. Furthermore, emerging evidence suggests that sustainability practices and reporting may interact differently with financial outcomes in women-led firms, highlighting the need for gender-sensitive analytical frameworks [9,16,26–28].

Overall, the literature reveals a convergence of regulatory pressure, conceptual ambiguity, and technological opportunity. However, it also exposes a more specific gap: although prior studies discuss SME reporting burden, digital transformation, and circular economy disclosure, they rarely organize these issues through an explicitly accounting-centered analytical structure. In particular, the literature has not sufficiently integrated ESG reporting requirements, circular economy information needs, gender-sensitive SME constraints, and digital enablement within the four interrelated domains of measurement, valuation, disclosure, and professional judgment. Addressing this gap constitutes the central contribution of the present study [10,13,14,19,24,26,29].

3. Materials and Methods

This study adopts a conceptual and interpretive analytical design aimed at developing an accounting-oriented framework for ESG and circular economy reporting in women-led SMEs. The study does not rely on primary empirical data collection or large-scale datasets. Instead, it combines regulatory analysis, purposive review of relevant academic literature, and selected bibliometric insights used as contextual input. The methodological objective is not statistical generalization, but analytical transparency in how reporting challenges are identified, grouped, and linked to potential digital responses.

3.1. Research Design and Sources

The research design combines three complementary sources of evidence:

1. EU regulatory and standard-setting documents, including the Corporate Sustainability Reporting Directive (CSRD), European Sustainability Reporting Standards (ESRS Set 1, including ESRS E5), and SME-oriented initiatives such as the Voluntary Sustainability Reporting Standard for SMEs (VSME) [1–4];
2. established academic literature on circular economy accounting, environmental management accounting, and ESG reporting [10–16,19–25,29]; and
3. previously published bibliometric and gender-inclusive analysis conducted by the authors (2015–2025), used here only as a contextual input for identifying underexplored thematic linkages, particularly the limited visibility of gender-sensitive perspectives in the digital circular economy literature [9].

Academic sources were selected purposively rather than through a formal systematic review protocol. Selection was guided by direct relevance to four thematic areas central to the study: SME sustainability reporting, circular economy accounting and disclosure, digitalization in accounting and reporting processes, and gender-related constraints affecting women-led enterprises. Priority was given to peer-reviewed academic publications, policy-relevant conceptual studies, and sources that directly informed the intersection of reporting requirements, accounting practice, and digital enablement.

Within the academic literature, emphasis was placed on sources that directly addressed accounting treatment, reporting implementation, SME proportionality, or digital reporting infrastructure, rather than on broader sustainability-transition literature lacking explicit reporting relevance.

All materials used in the study are publicly available and can be accessed through official EU institutional repositories, standard-setting bodies, and academic databases (e.g., Scopus-indexed

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literature). No proprietary datasets, confidential information, or restricted-access materials were employed.

The study is therefore positioned as a conceptual framework paper rather than an empirical explanatory model. Its purpose is theory-building and implementation structuring: to clarify how regulatory pressures, accounting challenges, and digital responses can be analytically connected in the specific context of women-led SMEs. The contribution of the paper lies in conceptual integration and structured interpretation, rather than in statistical inference or causal testing.

To provide an exploratory empirical extension of the conceptual framework, the study also incorporates a secondary analysis of publicly available documents and illustrative cases of women-led SMEs from the Danube Region. The purpose of this additional empirical layer is not statistical generalization, but analytical triangulation and practical contextualization of the proposed framework. The document corpus includes EU regulatory texts, SME-oriented reporting standards, public supplier sustainability questionnaires, finance-related ESG guidance, and WE.Circular support materials. The case-based layer draws on publicly accessible company websites, project materials, and profile sources for selected women-led SMEs identified through the WE.Circular initiative.

3.2. Analytical Procedure

The review process was purposive and thematic. Rather than applying a formal systematic-review protocol, the study organized the source base around recurring analytical themes emerging at the intersection of regulation, accounting practice, SME constraints, and digital enablement. The analytical process involved iterative thematic grouping and comparative mapping rather than formal coding in the empirical qualitative-research sense. Regulatory provisions, literature-based problem descriptions, and digitally enabled response options were compared across sources and then synthesized into a matrix linking challenge domains, accounting implications, and feasible digital responses.

The methodology follows a four-step analytical procedure designed to ensure replicability:

- Step 1: Regulatory Mapping. A structured review of EU sustainability reporting regulation was conducted to identify key reporting requirements relevant to SMEs. This includes (a) mandatory disclosure logic under CSRD, (b) ESRS-based reporting structures, including circular economy metrics under ESRS E5, and (c) digital reporting requirements such as electronic formats and taxonomy-based tagging [1–4].
- Step 2: Bibliometric-Based Conceptual Synthesis. Insights from a prior bibliometric and gender-inclusive study are incorporated only as a supporting interpretive layer, used to contextualize thematic gaps in the literature rather than to generate the main analytical structure of the present paper. The original dataset, methodology, and results of this bibliometric analysis are fully documented in the referenced publication. In the present study, these findings are used only to identify dominant research themes (e.g., digital enablers, traceability technologies) and to highlight the limited integration of gender perspectives in circular economy research [9].
- Step 3: Accounting Problem Structuring. Based on a comparative reading of regulatory requirements and the selected accounting literature, the study developed an "accounting challenge matrix." The four domains—measurement, valuation, disclosure, and professional judgment—were derived through iterative grouping of recurring reporting problems identified across the source base. More specifically, issues related to the quantification of resource flows and indicators were grouped under measurement; issues concerning monetary attribution, costing, and recognition under valuation; issues related to presentation, comparability, and reporting coherence under disclosure; and issues involving materiality assessment, assumptions, estimates, and boundary-setting under professional judgment. The classification is grounded in established accounting frameworks and environmental management accounting tools, including material flow cost accounting [22,24].

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In addition, the analysis explicitly differentiates between challenges that are structurally inherent to SMEs and those that are contextually intensified in women-led enterprises. This distinction is introduced at the interpretation stage, where literature on gender and entrepreneurship is used to identify mechanisms through which general reporting constraints may be amplified, including access to finance, digital capability gaps, and network participation [26–28].

- Step 4: Solution Mapping. Each identified accounting challenge is systematically linked to feasible digital solutions (e.g., data capture systems, automation tools, digital reporting infrastructure) and corresponding policy actions (e.g., harmonized data requests, training, subsidized infrastructure). This mapping reflects practical implementation pathways aligned with SME constraints and the broader Danube regional setting [10,12,15,29].
- Step 5: Exploratory Public-Data Illustration. To complement the conceptual analysis, the study applies a secondary public-data layer consisting of (a) document analysis and (b) comparative illustrative cases. The document analysis covers publicly available regulatory, standard-setting, finance-related, and market-facing materials relevant to SME sustainability reporting, including guidance documents, public questionnaires, and support resources. In parallel, seven illustrative women-led SMEs from the Danube Region were selected on the basis of publicly visible information regarding their sector, digital presence, circular or sustainability-related business model, and externally visible reporting or communication practices.

Each case was coded using a simple visibility-based scale (0 = not visible in public materials; 1 = indirectly or partially visible; 2 = clearly visible and repeated in public materials) across five analytical dimensions: measurement, valuation, disclosure, professional judgment, and digital readiness. In addition, the case review recorded sector, visible digital tools or readiness, ESG/circular disclosures present, evidence of challenge-domain visibility, and visible external reporting pressure. This coding does not claim to measure actual internal reporting quality, but rather the extent to which the proposed challenge domains can be identified through public-facing evidence.

3.3. Reproducibility and Data Availability

The study is transparent and traceable in its use of publicly accessible regulatory, academic, and case-related materials. As a conceptual and interpretive contribution with an exploratory empirical extension, its value lies not in reproducibility in the narrow statistical sense, but in the clarity of its analytical structure, source selection, coding logic, and reasoning process. The empirical extension relies exclusively on publicly available documents and company-facing materials, which can be accessed through official institutional repositories, standard-setting bodies, project platforms, and publicly accessible company websites. No proprietary datasets, confidential information, personal data, or restricted-access materials were employed. This study does not involve human participants, personal data, or animal subjects; therefore, ethical approval was not required.

4. Results: Accounting Challenges in ESG and Circular Economy Reporting for Women-Led SMEs

The results are structured according to the four accounting domains identified in the analytical framework. The results of the structured conceptual analysis are presented through four core accounting challenge domains: measurement, valuation, disclosure, and professional judgment. These domains emerge from the interaction between ESRS requirements, circular economy accounting complexity, and SME-specific constraints, particularly in the context of women-led enterprises.

While these domains are relevant to SMEs more broadly, the analysis in this section also highlights how their practical implications may be intensified in the context of women-led enterprises.

4.1. Exploratory Empirical Illustration Based on Publicly Available Documents and Cases

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To complement the conceptual framework, an exploratory empirical illustration was conducted using two public-data layers. First, a document analysis covered the CSRD/ESRS framework, the VSME standard, public supplier sustainability questionnaires, finance-related ESG guidance, and WE.Circular support materials. This document corpus indicates that SME-facing sustainability pressures are transmitted not only through regulation, but also through market-based questionnaires, financial-sector expectations, and capacity-building initiatives.

Second, seven illustrative women-led SME cases from the Danube Region were examined using publicly available evidence on sector, digital readiness, ESG/circular disclosures, challenge-domain visibility, and externally visible reporting pressure.

The selected cases provide a structured overview of how women-led SMEs in the Danube Region operationalize circular economy practices and communicate sustainability-related information in publicly accessible materials. The cases are not intended to be statistically representative, but rather to capture variation across sectors, levels of digital maturity, and visibility of ESG-related practices.

Table 1 summarizes the key characteristics of the selected SMEs, including sectoral positioning, observable digital tools, the presence of ESG or circular disclosures, and the visibility of external reporting pressures.

Table 1. Publicly visible case profiles of selected women-led SMEs from the Danube Region.

Case (Country)	Sector	Visible digital tools/readiness	ESG/circular disclosures present	External reporting pressure visible
SizeSense (Bulgaria)	Fashion-tech, SaaS	AI-based sizing, Shopify integration, digital partner-facing product	lower returns, lower emissions, less overstock, lower textile waste	Yes
Shengums/ SHEN Bugaria (Bulgaria)	Food, consumer goods	e-shop, newsletter, online product communication	biodegradable, plastic-free gum, sustainable packaging logic	Low
OilRight SRL (Romania)	Circular consumer products, social enterprise	web-site, e-shop, productized Oil2Wax technology	used cooking oil recycling, circular outputs, social mission	Moderate
AuTerra Materials (Slovenia)	Circular construction, secondary raw materials	mobile on-site technology, technical recovery solutions	secondary raw material recovery, mineral-waste solutions	Moderate to high
Sto.re/Textile Mountain (Czech Republic)	Textile reuse, repair, upcycling	website, public communication channels	reuse, repair, upcycling, deadstock recovery	Low to moderate
Neworn GmbH (Austria)	AI-driven circular e-commerce	AI-powered platform, app-based marketplace	product life extension, resale, textile waste reduction	Moderate
Moruša slow fashion (Slovakia)	Slow-fashion resale, curation	website, online shop, blog, curated resale service	second-hand curation, local resale, slow-fashion positioning	Low

As shown in Table 1, the selected cases exhibit substantial variation in terms of sector, digitalization level, and visibility of sustainability-related practices. While some firms—such as SizeSense and Neworn—demonstrate advanced digital integration and platform-based models, others rely on more basic digital infrastructures and communication channels.

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Across the seven cases, disclosure is the most publicly visible dimension, as nearly all firms communicate circularity, reuse, waste reduction, or sustainability-related value propositions in outward-facing materials. However, these disclosures are predominantly descriptive and narrative-driven, rather than systematically linked to formal accounting structures.

By contrast, more accounting-intensive domains—particularly valuation and professional judgment—are less directly observable in public-facing sources, even where circular business models are clearly present. This pattern indicates that public visibility tends to privilege sustainability narratives over the underlying accounting routines that support measurement, valuation, and decision-making.

To further structure the empirical illustration, the selected cases were systematically coded using a simplified visibility-based scale across the four accounting domains—measurement, valuation, disclosure, and professional judgment—alongside an additional dimension capturing digital readiness. The coding scale ranges from 0 (not visible in publicly available materials), through 1 (partially or indirectly visible), to 2 (clearly visible and repeatedly evidenced).

This approach does not aim to assess the internal quality or accuracy of ESG reporting, but rather to identify the extent to which accounting-relevant elements can be observed in publicly accessible information. By translating qualitative observations into a comparable structure, the coding enables the identification of recurring patterns across cases.

Table 2 presents the results of this comparative coding.

Table 2. Observed challenge patterns in publicly visible women-led SMEs.

Case (Country)	Measurement	Valuation	Disclosure	Professional judgment	Digital readiness
SizeSense (Bulgaria)	2	1	2	1	2
Shengums/ SHEN Bugaria (Bulgaria)	0	0	1	0	1
OilRight SRL (Romania)	2	1	2	1	1
AuTerra Materials (Slovenia)	2	1	1	1	2
Sto.re/Textile Mountain (Czech Republic)	1	1	2	1	1
Neworn GmbH (Austria)	1	1	2	1	2
Moruša slow fashion (Slovakia)	0	1	2	1	1

The comparative coding reveals three consistent patterns. First, digital readiness is most visible in platform-based or technology-intensive cases such as SizeSense and Neworn, indicating a stronger capacity for structured data processing and reporting. Second, measurement-related elements are more evident in cases built on waste recovery, material transformation, or secondary raw materials, such as OilRight and AuTerra Materials, where physical resource flows are central to the business

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model. Third, valuation and professional judgment remain comparatively underexposed in publicly available materials, despite their likely operational importance.

This pattern indicates that digitalization enhances the visibility and organization of disclosure, while more complex accounting domains—particularly those requiring estimation, valuation, and interpretive judgment—remain less externally observable and more difficult to structure in smaller firms. This finding supports the paper's broader argument that digitalization improves reporting accessibility but does not automatically resolve deeper accounting challenges.

4.2. Measurement Challenge: From Circular Practices to Auditable Indicators

The introduction of ESRS E5 formalizes "resource use and circular economy" as a standardized disclosure area, requiring firms to report comparable and, increasingly, machine-readable indicators [2]. For women-led SMEs, the primary challenge lies in translating heterogeneous circular practices—such as reuse, repair, remanufacturing, and waste reduction—into consistent, auditable metrics.

Measurement difficulties arise in four main areas: (i) tracking physical resource inflows and outflows; (ii) defining system boundaries (organizational versus value-chain scope); (iii) ensuring data consistency over time; and (iv) linking operational data to accounting systems. These challenges are intensified by the lack of standardized circular indicators and by the diversity of circular economy strategies documented in the literature [19–21].

From an accounting perspective, measurement becomes feasible when physical resource tracking is embedded into existing accounting or inventory systems. Tools such as material flow cost accounting (MFCA) provide a practical starting point, enabling SMEs to quantify material losses and connect them to monetary values [22]. However, without digital support—such as structured data capture and automated tracking—measurement remains fragmented and difficult to scale [23,25].

4.3. Valuation Challenge: Assigning Monetary Meaning to Circular Activities

The transition to circular economy models introduces significant valuation complexity [24]. Traditional accounting systems are not designed to fully capture the economic implications of circular activities, such as reuse, refurbishment, or waste reduction. As a result, many circular practices remain partially or inconsistently reflected in financial statements.

Key valuation challenges include: (i) assigning value to waste and by-products; (ii) determining the cost and profitability of refurbished or circular products; (iii) recognizing circular investments and transition-related expenditures; and (iv) dealing with uncertainty due to the absence of stable market prices for secondary materials [21,24].

For women-led SMEs, valuation challenges are closely linked to access to finance [16,28]. Inconsistent or non-transparent valuation practices may reduce the credibility of sustainability claims in interactions with lenders, investors, or supply-chain partners. Consequently, valuation is not merely a technical issue but a strategic factor influencing financial inclusion and business opportunities.

The findings suggest that simplified, rule-based valuation approaches—combined with digital tools for cost tracking and documentation—can significantly improve consistency and transparency without imposing excessive burden [18,23,25].

4.4. Disclosure Challenge: Connectivity, Comparability, and Reporting Fragmentation

The CSRD and ESRS framework fundamentally reshapes disclosure by requiring sustainability information to be integrated within the management report and aligned with financial reporting [1,2]. This creates a "system-level" challenge for SMEs, which must ensure consistency, comparability, and connectivity across different types of information.

In practice, SMEs face three major disclosure-related problems:

1. Fragmented and duplicative ESG data requests from multiple stakeholders (buyers, banks, public authorities) [13,14];

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2. Lack of standardized reporting formats; and
3. Limited internal capacity to produce coherent sustainability narratives.

Women-led SMEs are particularly affected by these issues due to resource constraints and weaker access to specialized expertise [26–28]. The absence of harmonized reporting frameworks increases administrative costs and the risk of inconsistent disclosures.

The analysis highlights the importance of the Voluntary Sustainability Reporting Standard for SMEs (VSME) as a coordination mechanism [3,4]. When used as a common reference point, VSME can reduce duplication, improve comparability, and support more efficient reporting processes.

Digitalization plays a central role in addressing disclosure challenges by enabling centralized data management, automated reporting outputs, and preparation for future digital tagging requirements [10,12,15,25].

4.5. Professional Judgment Challenge: Materiality, Estimation, and Assurance Readiness

Professional judgment is a critical component of ESG and circular economy reporting, particularly under the ESRS framework, which is grounded in the concept of double materiality [2]. SMEs must assess which impacts, risks, and opportunities are material, often under conditions of uncertainty and limited data availability.

Three main areas of judgment emerge: (i) materiality assessment and prioritization of ESG topics; (ii) estimation of indicators where direct measurement is not feasible; and (iii) definition of value-chain boundaries and data sources.

These challenges are amplified by increasing assurance expectations, as EU-level limited assurance standards are expected to apply in the near future [1,2,17]. SMEs lacking structured documentation, internal controls, and audit trails face higher risks of non-compliance and credibility gaps.

For women-led SMEs, the burden of professional judgment may be disproportionately high due to digital skill gaps and limited access to advisory services. This creates a potential "reporting inequality," where firms with weaker capabilities incur higher costs and risks [26–28].

The results indicate that digital tools—such as assumption registers, workflow approvals, and version control systems—can significantly improve the transparency and defensibility of professional judgments [10,12,15,25]. These tools transform judgment from an implicit process into a documented and auditable component of reporting.

5. Conceptual Framework: Digitalization as an Accounting Enabler for ESG and Circular Reporting

Building on the identified accounting challenges, this study develops a conceptual framework explaining how digitalization can support ESG and circular economy reporting in women-led SMEs within the CSRD/ESRS environment. The framework functions as a conceptual organizing model with practitioner and policy relevance, offering an accounting-based lens for interpreting sustainability reporting challenges while also supporting staged digital implementation and proportional SME support.

The framework integrates external reporting drivers, SME-specific contextual conditions, accounting challenge domains, digital accounting capabilities, and resulting reporting outcomes into a coherent analytical structure. Rather than treating digitalization as a purely technological layer, it is conceptualized as an enabling accounting infrastructure that connects regulatory expectations with operational reporting practices [10,12,15,25,29]. From an analytical perspective, the framework is best understood as a layered and conditional model rather than a linear sequence. Regulatory and market-driven pressures act as primary drivers, while SME-specific conditions—particularly those affecting women-led enterprises—moderate how these pressures are experienced in practice.

Within this structure, the four accounting challenge domains—measurement, valuation, disclosure, and professional judgment—represent the operational layer through which sustainability

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reporting requirements are translated into accounting practice. These domains are interdependent: measurement concerns the quantification of resource flows and circularity indicators; valuation addresses the assignment of monetary meaning to circular activities and sustainability investments; disclosure focuses on structuring and communicating ESG information; and professional judgment encompasses materiality, estimation, and boundary-setting decisions. Choices in one domain directly influence outcomes in the others [22,24].

Digital accounting capabilities constitute the central enabling mechanism linking these challenges to feasible solutions. These capabilities include structured data capture, integration of sustainability data with accounting systems, automation of reporting processes, and preparation of standardized, tagging-ready datasets supported by audit trails and documentation [10,12,15,23,25,29]. In this sense, digitalization both mediates and conditions the relationship between regulatory pressure and reporting outcomes: it mediates by transforming fragmented data into structured, auditable information, and it conditions outcomes by determining the extent to which SMEs can achieve comparability, reliability, and assurance readiness. This framing captures a system of interdependent relationships rather than a simple cause–effect chain.

At the input level, the framework reflects the combined influence of regulatory and market-driven pressures. CSRD and ESRS introduce requirements related to double materiality, standardized disclosures, and digital reporting formats, while market actors increasingly demand sustainability data from SMEs, creating a "cascade effect" beyond formal regulatory scope [1–4,13,14]. These pressures are filtered through SME-specific constraints, including limited capacity, digital skill gaps, and structural inequalities, which are often more pronounced in women-led enterprises.

The implementation of digital accounting capabilities enables SMEs to move from fragmented and ad hoc reporting toward more systematic and scalable processes. This transition generates intermediate outputs such as minimum viable ESG and circular datasets, alignment with standardized reporting structures, and improved traceability of data and assumptions. These outputs contribute to broader outcomes, including reduced reporting burden, enhanced comparability and credibility, and improved access to markets, supply chains, and finance. The framework also incorporates a dynamic feedback mechanism, whereby repeated reporting cycles support organizational learning and continuous improvement.

A distinctive feature of the framework is its explicit gender-sensitive dimension. Women-led SMEs often face structural constraints related to access to finance, digital skills, and participation in innovation-intensive sectors, which increase both the cost and risk of sustainability reporting [15,16,28]. In this context, digitalization performs a dual role: it acts as a risk mitigation mechanism by reducing reliance on external expertise and improving reporting consistency, and as an empowerment mechanism by enabling the production of credible, standardized, and comparable sustainability information. Digital accounting capabilities thus function not only as technical tools but also as instruments for addressing structural inequalities in sustainable and circular transitions.

Overall, the framework should be interpreted as a relational model linking drivers, capabilities, and outcomes through enabling and conditioning mechanisms, rather than as a strictly sequential process. The relationships between regulatory drivers, accounting challenges, digital capabilities, and reporting outcomes are summarized in Figure 1.

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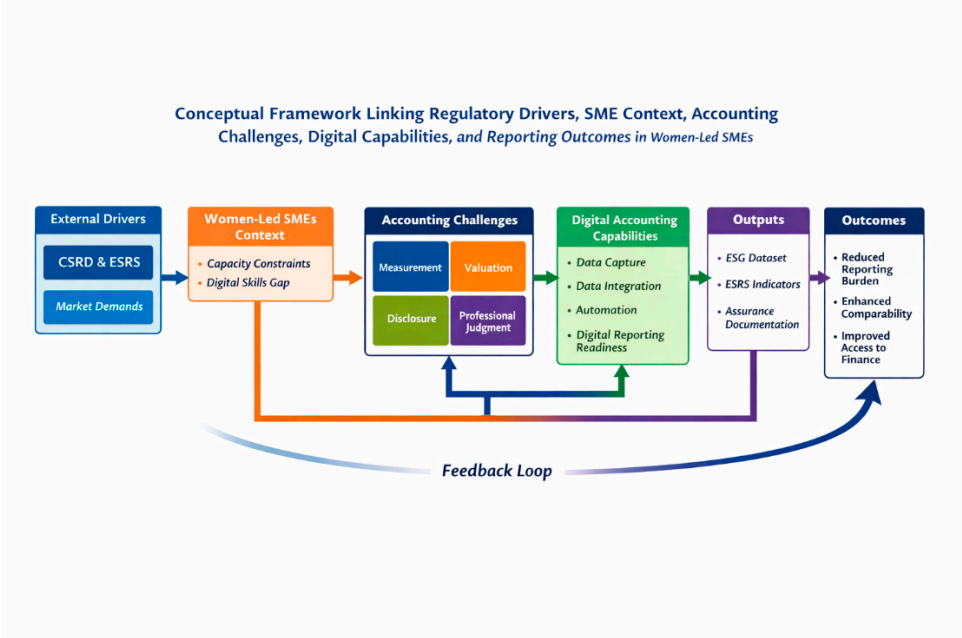

Figure 1. Conceptual framework linking regulatory drivers, SME context, accounting challenge domains, digital accounting capabilities, and reporting outcomes in women-led SMEs under the CSRD/ESRS environment.

The figure illustrates the relational structure of the proposed framework, emphasizing the non-linear interaction between regulatory pressures, SME-specific conditions, accounting challenges, and digital enabling mechanisms. External drivers—stemming from the CSRD/ESRS framework and market-based sustainability data demands—initiate reporting requirements that are operationalized through four interrelated accounting domains: measurement, valuation, disclosure, and professional judgment.

Digital accounting capabilities act as a mediating and conditioning layer, enabling the transformation of fragmented data into structured, auditable, and comparable information. Through this mechanism, SMEs can progressively develop reporting outputs such as minimum viable ESG datasets, standardized disclosures, and traceability-enhanced information structures. These outputs, in turn, contribute to broader outcomes, including reduced reporting burden, improved comparability, and enhanced access to finance.

The framework also incorporates a feedback loop, reflecting how repeated reporting cycles support organizational learning and incremental capability development. Importantly, SME-specific contextual conditions—particularly those affecting women-led enterprises—moderate each stage of the process, influencing both the feasibility and effectiveness of digital and accounting solutions.

This positioning reinforces the interpretation of digitalization not as a standalone technological solution, but as an embedded accounting capability shaping the quality and feasibility of sustainability reporting.

6. Discussion

This study seeks to contribute to the growing body of research on ESG and circular economy reporting by introducing an accounting-centered and gender-sensitive perspective on digitalization in SMEs. While prior literature has widely emphasized the role of digital technologies as enablers of circular economy transitions, the findings of this study suggest that digitalization becomes effective only when embedded within structured accounting processes capable of supporting measurement, valuation, disclosure, and professional judgment [10,12,15,23–25].

The results reinforce existing research highlighting the complexity of sustainability reporting for SMEs, particularly under expanding regulatory frameworks such as the CSRD and ESRS. Consistent with prior studies, the analysis confirms that SMEs face significant challenges in translating abstract

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sustainability concepts into measurable, comparable, and decision-useful information. However, this study adds to the literature by proposing that these challenges are fundamentally accounting-related, rather than purely technical or regulatory. In this sense, the paper shifts the focus from "reporting compliance" toward "accounting capability," positioning accounting systems as the core infrastructure for sustainability reporting [11,13,14,17,18,24].

The findings contribute to the ongoing debate on the role of digitalization in sustainability reporting. While many studies present digital tools as efficiency-enhancing solutions, the present analysis highlights a critical limitation: digitalization alone does not reduce reporting burden unless it is aligned with accounting logic and organizational routines. This finding supports and refines prior arguments that emphasize the need for integration between digital technologies and accounting systems. The conceptual framework developed in this study explicitly captures this relationship by positioning digital accounting capabilities as an enabling layer rather than a standalone solution [10,12,15,29].

However, it is important to acknowledge that digitalization also introduces a set of constraints and risks that may limit its effectiveness, particularly in resource-constrained SME contexts. First, the implementation of digital reporting systems may entail non-trivial upfront and ongoing costs, including software acquisition, customization, and staff training, which can be difficult to absorb for smaller firms. Second, interoperability challenges between different software systems and reporting platforms may create additional complexity, especially in fragmented value chains where multiple stakeholders require different data formats. Third, increased reliance on external software providers may generate forms of vendor dependency, reducing flexibility and potentially exposing SMEs to lock-in effects. Fourth, digitalization raises important concerns related to cybersecurity, data governance, and the protection of sensitive business information, particularly when ESG data becomes more granular and externally shared. Finally, there is a risk that digital reporting requirements may inadvertently reproduce or deepen existing inequalities, as firms with stronger digital capabilities are better positioned to comply efficiently, while others face higher relative costs and risks [12,25,29].

In this sense, digitalization should not be interpreted as an inherently equalizing force, but rather as a capability-dependent mechanism whose benefits depend on access to resources, skills, and institutional support. A balanced approach therefore requires not only technological adoption, but also targeted capacity-building and proportional policy design [15,29].

The analysis further extends this perspective by incorporating a gender-sensitive dimension into the interpretation of ESG and circular economy reporting challenges [9,26–28]. Existing bibliometric and conceptual research indicates that gender-related aspects remain underrepresented in studies on digital circular economy transitions. By focusing on women-led SMEs, this paper demonstrates that sustainability reporting is not a neutral technical process, but one that interacts with structural inequalities, including access to finance, digital skills, and professional networks. The findings suggest that reporting requirements and assurance expectations may have distributional effects, potentially amplifying existing disparities if not accompanied by targeted support mechanisms.

At this point, it is important to distinguish between challenges that are common to SMEs in general and those that are specifically intensified in women-led SMEs. The four accounting domains identified in this study—measurement, valuation, disclosure, and professional judgment—represent structural reporting challenges that affect SMEs regardless of ownership characteristics. These challenges arise from limited resources, lack of standardized data, and increasing regulatory and market pressures.

However, the analysis suggests that in women-led SMEs these challenges are not fundamentally different in type, but are often amplified in intensity, cost, and risk exposure. More precisely, the paper does not argue that women-led SMEs face a distinct category of sustainability reporting problems. Rather, it shows that the same accounting challenges may become more difficult to manage because they are filtered through unequal access to finance, weaker access to specialized advisory support, slower digital capability formation, and less stable participation in formal business and

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reporting networks. The gender-sensitive contribution of the paper therefore lies in explaining intensification mechanisms, not in claiming categorically different reporting obligations. This intensification occurs through several interrelated mechanisms. First, women-led SMEs are more likely to face constraints in access to finance and specialized advisory services, which limits their ability to outsource or support complex accounting and reporting tasks. Second, documented digital skill gaps and lower participation in technology-intensive sectors may slow the adoption of digital reporting tools, increasing reliance on manual processes and reducing data consistency. Third, weaker integration into formal business networks and value chains may expose these firms to more fragmented and non-standardized ESG data requests, increasing administrative burden [16,26–28].

In this sense, the gender-sensitive perspective adopted in this study does not imply a separate category of accounting challenges, but rather highlights how existing reporting requirements may have uneven effects across SME populations. This distinction is important for both analytical clarity and policy design, as it suggests that proportional support measures should address not only firm size, but also structural inequalities affecting specific groups of enterprises.

To further clarify this distinction, Table 3 summarizes how general SME reporting challenges are amplified in women-led SMEs through specific structural mechanisms.

Table 3. General SME reporting challenges and their intensification in women-led SMEs.

Accounting challenge domain	General SME challenge	Intensification in women-led SMEs	Mechanism of intensification
Measurement	Difficulty in tracking resource flows and generating consistent ESG indicators	Higher reliance on manual data collection and fragmented data sources	Limited access to digital tools and lower digital capability levels
Valuation	Uncertainty in assigning monetary value to circular activities and secondary materials	Reduced ability to validate or benchmark valuation assumptions	Constraints in access to financial expertise and advisory services
Disclosure	Fragmented ESG data requests and lack of standardized reporting formats	Higher administrative burden and risk of inconsistent disclosures	Weaker integration into standardized value chains and reporting networks
Professional judgment	Complexity in materiality assessment, estimation, and boundary-setting	Increased risk of error and lower assurance readiness	Limited access to training, expertise, and formalized internal processes

As shown in Table 3, this differentiation is not based on distinct categories of accounting challenges, but on differences in their practical intensity and manageability [26–28]. This perspective reinforces the argument that gender-sensitive analysis in sustainability reporting should focus on differential capacity, access, and exposure rather than on fundamentally distinct reporting requirements.

The results highlight a key tension between standardization and proportionality in sustainability reporting. On the one hand, harmonized frameworks such as ESRS and digital reporting formats improve comparability and transparency. On the other hand, they may impose disproportionate burdens on SMEs, particularly those with limited resources. The analysis suggests that initiatives such as the Voluntary Sustainability Reporting Standard for SMEs (VSME) can play a critical role in balancing these objectives by providing simplified and coordinated reporting structures. In this context, digitalization can support proportionality by enabling scalable, low-burden reporting solutions tailored to SME capabilities [2–4,13,14].

The study contributes to the emerging literature on circular economy accounting by emphasizing the need to integrate physical resource flows with financial information. Consistent

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with prior research on environmental management accounting and material flow cost accounting, the findings show that circular economy reporting requires accounting systems capable of capturing resource efficiency, material losses, and value retention across extended value chains. The proposed framework advances this perspective by linking these requirements to digital capabilities that facilitate data capture, integration, and traceability [22–24].

Overall, the discussion underscores that the effectiveness of ESG and circular economy reporting in SMEs depends on the alignment of three elements: regulatory expectations, accounting capabilities, and digital infrastructure. Digitalization plays a pivotal role in this alignment, but its impact is contingent upon the existence of coherent accounting practices and institutional support. The study therefore advances the literature by conceptualizing digitalization not as an end in itself, but as a means of operationalizing sustainability reporting in a way that is both technically feasible and socially inclusive [10,12,15,24,29].

In doing so, the paper provides a bridge between regulatory developments, accounting theory, and SME practice. It also highlights the importance of designing sustainability reporting frameworks that are sensitive to firm size, resource constraints, and gender-related structural conditions. These insights are particularly relevant in the context of the Danube Region and related regional initiatives, where digital capacity building and inclusive entrepreneurship are central policy priorities [6,7].

The exploratory public-data illustration presented in this study provides an initial empirical contextualization of the proposed framework, but future research should test these mechanisms more directly through case studies, interviews, surveys, or mixed-method designs focused on internal reporting practices and implementation outcomes.

Future research should empirically test the proposed framework across different SME contexts and regulatory environments.

7. Policy, Practical Implications, and Limitations

The findings of this study carry important implications for policymakers, practitioners, and researchers engaged in sustainability reporting and circular economy transition, particularly in the context of women-led SMEs operating under increasing regulatory and market pressures.

From a policy perspective, the results highlight the need for greater alignment between regulatory ambitions and SME capabilities. While the CSRD and ESRS significantly enhance transparency and comparability, their indirect effects on SMEs—through value-chain reporting requirements—may create disproportionate burdens [1,2,13,14]. In this context, the Voluntary Sustainability Reporting Standard for SMEs (VSME) emerges as a critical coordination mechanism [3,4]. Policymakers at both EU and regional levels, particularly within the Danube Region, should promote the systematic adoption of VSME as a reference framework for sustainability data requests from large companies, financial institutions, and public procurement systems [6,7]. Such harmonization would reduce fragmentation, lower administrative costs, and improve the consistency of reported information.

In addition, targeted public support is necessary to address the digital and capacity gaps identified in women-led SMEs [26–29]. This includes investment in accessible digital reporting infrastructure, development of standardized templates and data dictionaries, and the provision of training programs focused on digital accounting capabilities. Transnational and regional support initiatives can play a key role in delivering these interventions, particularly through practical training modules, shared tools, and knowledge exchange. Policies that combine sustainability reporting requirements with capacity-building measures are more likely to achieve both compliance and inclusion objectives.

From a practical standpoint, the study provides actionable guidance for SMEs, accountants, and advisors. A central recommendation is the adoption of a “minimum viable ESG and circular dataset” approach, aligned with VSME principles, which allows firms to respond efficiently to multiple stakeholder demands while controlling reporting costs [3,4,18]. SMEs should prioritize the integration of sustainability-related data into existing accounting systems, particularly by linking

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physical resource flows with financial information through management accounting practices such as material flow cost accounting [3,4,22].

For practitioners, the value of the framework lies in three concrete applications: first, it helps SMEs define a minimum viable ESG and circular dataset; second, it supports staged and resource-sensitive digitalization of reporting processes; and third, it offers policymakers and data requesters a basis for reducing fragmentation through more harmonized sustainability information requirements.

To operationalize these implications, Table 4 presents a structured mapping of key accounting challenges to corresponding digital solutions and policy actions. The table is designed as a practitioner-oriented matrix that translates the conceptual framework into concrete implementation pathways, particularly relevant for women-led SMEs operating under resource and capability constraints.

Table 4. Accounting challenges, digital solutions, and policy actions for ESG and circular economy reporting in women-led SMEs.

Challenge	Accounting implication	Digital solution	Policy action
Incomplete tracking of resource inflows/outflows	Inconsistent circular KPIs and limited visibility of material losses	Resource flow ledger linked to accounting/inventory systems; MFCA-based templates	Promote VSME-aligned datasets; subsidize SME-ready tools
Boundary ambiguity (organizational vs value chain)	Reduced comparability and inconsistent disclosures	Stakeholder-based data mapping with documented assumptions	Harmonize reporting requests; develop SME sector guidance
Weak linkage between physical metrics and costs	Poor investment appraisal of circular activities	Integration of physical data into cost centers and dashboards	Training on circular cost drivers; digital bookkeeping support
Valuation of waste and circular outputs	Misstated margins and inconsistent inventory valuation	Separate accounting codes; rule-based costing; documented assumptions	Guidance on simplified valuation approaches; market data access
Undocumented estimation and proxies	Low assurance readiness and higher error risk	Assumption registers, version control, automated validation	Develop SME-oriented assurance readiness frameworks
Fragmented ESG data requests	High administrative burden and duplication	Centralized ESG dataset with automated outputs	Promote VSME as common reporting standard
Limited internal controls	Reduced reliability of ESG data	Workflow approvals, audit trails, access controls	Proportional internal control guidance for SMEs
Lack of digital reporting readiness	Future compliance risks and high transition costs	Tagging-ready data structures and standardized outputs	Public support for digital reporting infrastructure
Skills constraints	Slow adoption and dependency on external expertise	Training modules, low-code tools, shared services	Targeted capacity-building through regional training initiatives
Limited ability to communicate with financiers	Reduced access to finance	Automated ESG summary dashboards for stakeholders	Incentivize standardized SME disclosures in finance

As shown in Table 4, the integration of digital accounting capabilities with simplified reporting approaches enables SMEs to address multiple reporting challenges simultaneously, while reducing administrative burden and improving data reliability [10,15,23,25].

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Furthermore, the selection of digital tools should be guided not by their visual or analytical sophistication, but by their ability to ensure data traceability, consistency, and audit readiness. Features such as workflow controls, version tracking, and documentation of assumptions are essential for meeting emerging assurance expectations. For accountants and advisors, this implies a shift toward integrating sustainability considerations into core accounting processes rather than treating them as separate reporting exercises [10,12,15,25].

The findings are also relevant for financial institutions and large companies acting as data requesters. Accepting standardized SME disclosures, particularly those aligned with VSME, instead of imposing customized questionnaires, would significantly reduce reporting fragmentation and support more efficient value-chain data flows. This approach would also improve the comparability and usability of sustainability information across supply chains [3,4,13,14,16].

Despite these contributions, the study has several limitations that should be acknowledged. First, although the study incorporates an exploratory empirical extension based on publicly available documents and illustrative cases, it does not rely on primary empirical data. The findings should therefore be interpreted as analytically supportive rather than statistically generalizable. Future research should validate the framework through interviews, surveys, case studies, or field-based implementation analysis.

Second, the regulatory environment is evolving, with ongoing discussions on simplification measures and SME-specific reporting guidance. As such, some of the assumptions underlying the framework may require adjustment as new standards, interpretations, or implementation practices emerge. Continuous monitoring of regulatory developments is therefore necessary [3,4,17].

Third, women-led SMEs are not a homogeneous group. Differences across sectors, countries, and institutional contexts—particularly within the diverse Danube macro-region—may influence the applicability of the proposed framework. Future research should explore these variations and examine how local conditions affect digital adoption and reporting practices [6,7,28].

Finally, further investigation is needed into the potential distributional effects of sustainability reporting requirements [16,26–28]. In particular, future studies could examine whether digitalization and standardized reporting frameworks reduce or reinforce existing inequalities in access to finance, market participation, and business growth among women-led SMEs.

Overall, this section underscores that effective sustainability reporting for SMEs requires not only regulatory alignment but also practical feasibility and inclusiveness. By combining accounting logic, digital capabilities, and gender-sensitive considerations, the study provides a foundation for more balanced and implementable sustainability reporting systems.

8. Conclusions

This study has shown that the sustainability reporting challenges faced by women-led SMEs in the CSRD/ESRS environment can be interpreted most productively through an accounting lens. Rather than treating ESG and circular economy reporting as a purely regulatory or technological issue, the paper demonstrates that the core implementation difficulties cluster around four interrelated domains: measurement, valuation, disclosure, and professional judgment. Within this structure, digitalization functions not as an isolated solution, but as an enabling accounting infrastructure that can improve traceability, comparability, auditability, and implementation feasibility. The study's main contribution is the development of a conceptual framework that links regulatory pressures, SME-specific constraints, digital accounting capabilities, and reporting outcomes in a coherent and practice-oriented model.

The study also advances the literature by incorporating a gender-sensitive perspective, highlighting how structural constraints faced by women-led SMEs may influence their ability to comply with sustainability reporting requirements and to benefit from emerging opportunities. In this regard, digitalization is shown to have the potential not only to improve reporting efficiency, but also to reduce inequalities by enabling more accessible and standardized reporting processes.

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From a practical and policy standpoint, the results suggest that scalable, low-burden reporting approaches—such as minimum viable ESG datasets and VSME-aligned disclosures—are essential for ensuring that sustainability reporting remains both feasible and inclusive. At the same time, investments in digital capabilities, training, and harmonized data frameworks are necessary to support SMEs in this transition.

In conclusion, the paper argues that the effectiveness of ESG and circular economy reporting for SMEs depends on the alignment of regulatory frameworks, accounting practices, and digital infrastructure. By providing an integrated and application-oriented perspective, this study contributes to bridging the gap between regulatory expectations and practical implementation, particularly in the context of women-led SMEs operating within regional transition and capacity-building environments.

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Data Availability Statement: This study relies exclusively on publicly available regulatory, academic, and company-level sources. All materials used in the analysis are cited in the reference list and can be accessed through official EU institutional repositories, standard-setting bodies, and publicly accessible company websites. No new datasets were generated; the exploratory empirical illustration is based on publicly accessible documents and company-level information.

Conflicts of Interest: The authors declare no conflicts of interest.

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