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Accounting for Renewable Energy: Investigating Emerging Topics and Research Pathways

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ABSTRACT

This paper presents a structured and systematic literature review (SLR) and critique of the literature on the opportunities and challenges of accounting, auditing, and renewable energy sources to identify trends and research streams and construct an agenda for future research. We collected a corpus of 229 academic articles searching in the 89 Chartered Association of Business School (CABS) accounting journals ranked 1, 2, 3, 4, and 4* over a period of 22 years. A total of 32 academic articles were included in the core analysis showing a total number of 2418 citations. We identify three research streams, namely 1) sustainability accounting and accounting for renewable energy; 2) the relationship between accounting, institutions, and the environment; and 3) environmental accounting, management, and sustainable development. The main theoretical and practical implications of this paper's findings are that the role of accounting and auditing for renewable energy is a prominent research topic for academics, practitioners, decision-makers, and policy-makers to consider.

1 | Introduction

Human activity has produced intensive impacts on Earth's ecosystem that can no longer be mitigated by the environment itself (Charnock and Hoskin 2020; Nicolò et al. 2021; Solomon et al. 2011). The academic literature explains this phenomenon through the transition from the Holocene to the Anthropocene, an era in which human action is a determinant of global environmental change, where “telecoupling” now prevails (Bebbington et al. 2020; Jabot 2023). Telecoupling highlights how alterations in one aspect of a socioeconomic system can generate repercussions elsewhere (Bebbington and Rubin 2022).

Global warming and its effects across the globe have attracted the attention of world governments, as the changes taking place in Earth's ecosystem require decisive and coordinated responses (Wang and Zhou 2022). As a result, most countries, including the major world powers, have committed to implement measures to lower greenhouse gas emissions (GHG), aimed at achieving climate objectives that are also in line with the United Nations Sustainable Development Goals (SDGs) (Bebbington and Unerman 2018). These commitments have led governments to prioritize energy sources other than fossil fuels and adopt semi-urbanization policies in order to reduce carbon emissions (Wang et al. 2022; Wang and Zhou 2022).

Abbreviation: AHP, Analytical Hierarchical Process; CABS, Chartered Association of Business School; CDM, Clean Development Mechanism; COEC, cost of equity capital; COPs, Conference of the parties; CPY, citations per year; EID, environmental information disclosure; EMA, Environmental management accounting; GHG, Greenhouse Gas emissions; GRI, global reporting initiative; IASB, International Accounting Standards Board; IEA, International Energy Agency; IPCC, Intergovernmental Panel on Climate Change; LCA, life cycle assessment; MACS, management accounting and control systems; RAC, Russian American Company; RED, Renewable Energy Directive; SDGs, Sustainable Development Goals; SLR, structured and systematic literature review; TCFD, Task Force on Climate-related Financial Disclosures.

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Renewable energies have the advantage of providing energy without the negative externalities produced by fossil fuels (Aleixandre-Tudó et al. 2019). Renewable energy sources are considered necessary for sustainable development, but they do not produce significant impacts on the environment, are inexhaustible, and are therefore called clean energy (Panwar et al. 2011). It is estimated that 80% of worldwide energy still derives from fossil fuels (Aleixandre-Tudó et al. 2019).

To deal with the increase in the average global temperature and the recent energy crisis, the European Union's energy policy promotes renewable energy sources, setting the objective of 32% by 2030. The European Union has regulated this issue with the Directive 2018/2001/EU (or EU Directive), also providing a definition of renewable energy. By integrating definitions from the literature and recent EU regulations, renewable energy sources can be defined as “energy from renewable non-fossil sources, namely wind, solar (solar thermal and solar photovoltaic) and geothermal energy, ambient energy, tide, wave and other ocean energy, hydropower, biomass, landfill gas, sewage treatment plant gas, biogas” and bioenergy (EU Directive 2018/2001; Ellabban et al. 2014). The report of the International Energy Agency (IEA) et al. (2024) on progress toward achieving SDG 7 highlights that, despite significant advancements, substantial efforts are still required to reach the goal (International Energy Agency 2022). The share of renewable energy in total final energy consumption has risen by only 2%, from 16.7% in 2015 to 18.7% in 2021. The model introduced by the Task Force on Climate-related Financial Disclosures (TCFD), which also shifts attention towards the opportunities of climate change, raises awareness of the issue of accounting for renewable resources. This theme opens an important space for accounting academics to investigate and contribute to, which has led to much recent interest in carbon disclosure and performance among accounting scholars (Liesen et al. 2015; O'Dwyer and Unerman 2020). The view has been expressed that accounting must take up the challenge posed by renewable resources so that it can facilitate the transition to zero emissions (Maama and Appiah 2019; Muscio et al. 2023), e.g. with links to performance management, while providing suitable measurement tools (Burritt and Schaltegger 2012). Accounting provides the means to estimate costs and investments in renewable energy sources.

Several authors argue that there is a need to investigate the role of accounting and new technologies supporting accounting in promoting the pursuit of the SDGs (Unerman et al. 2018; Manes-Rossi and Nicolò 2022). There is growing evidence of the importance of management accounting and control systems for the planning, evaluation, and decision-making of practices aimed at reducing environmental impacts (Gomez-Conde et al. 2019). Furthermore, accounting could represent a means for the more accurate measurement of risks and opportunities for businesses, the environment, and communities, deriving from the move towards systems based on renewable energy (Bebbington et al. 2021).

This paper aims to bridge a gap by exploring the academic literature on accounting, auditing and renewable energy sources. Existing studies have focused more on climate change and other environmental issues (Adams et al. 2024; Gulluscio et al. 2020; Khalifa et al. 2024). Christensen et al. (2024) highlight the need

to rethink auditing practices to address the evolving sustainability challenges. Although their work explores the relationship between climate change and accounting, it does not emphasize renewable energy. According to Schaltegger et al. (2024 “*a broader conceptualization of renewable energies is needed*” (p. 2). Then, our study is based on a structured and systematic review and critique of the literature on the opportunities and challenges of accounting, auditing, and renewable energy sources to identify emerging debates and research opportunities.

Our structured and systematic literature review (SLR) (Asmussen and Møller 2019; Garanina et al. 2022; Petticrew and Roberts 2006; Massaro et al. 2016; Lombardi et al. 2022), identifies relevant articles published in 1, 2, 3, 4, and 4* accounting journals, as ranked by the Chartered Association of Business Schools (CABS) during the last 22 years (2002–2023). We retrieved 229 documents published in journals. After screening these documents, a final list of 32 academic articles was identified as the dataset. We applied content, citation, and bibliometric analyses to this dataset.

We applied the Alvesson and Deetz (2000) study to set “insight”, “critique” and “transformative” issues in the analysis. Additionally, we defined the research questions as follows (Garanina et al. 2022; Massaro et al. 2016):

- RQ1. What is the state of the art for investigating accounting, auditing and renewable energy sources?
- RQ2. What is the focus and critique of literature within the accounting, auditing and renewable energy sources?
- RQ3. What is the future research for accounting, auditing and renewable energy sources?

Research questions 1 and 2 allowed to draft the state of the art in the topic, while research question 3 provides the transformative redefinition in the analysis and implications.

Our findings are the first to identify opportunities and challenges of accounting, auditing, and renewable energy sources in this emerging field. We draft the state of the art through the identification of three emerging research streams, namely 1) sustainability accounting and accounting for renewable energy; 2) the relationship between accounting, institutions, and the environment; and 3) environmental accounting, management, and sustainable development. Our research evidence has implications for, and will be useful to, academics, practitioners, professionals, decision-makers, and policy-makers. The main theoretical and practical implications reflect opportunities and challenges. First of all, accounting and auditing for renewable energy or alternative energy is a prominent research topic for academics and important for practitioners and decision-makers (Ascuí and Lovell 2011; Brown and Dillard 2014; Burritt and Schaltegger 2012; Charnock and Thomson 2019; Fonseka et al. 2019; Green and Li 2012; Haque and Deegan 2010; Martinov-Bennie 2012; Matsumura et al. 2014; Sharma et al. 2018). This is an emerging stream of research offering opportunities, such as tools and methods of measurement, reporting and disclosure, auditing, and assurance for addressing alternative energy issues at the corporate level. Challenges could be defined in more detail, as this is an emerging research topic.

Secondly, accounting techniques can be used by policymakers as a tool to improve sustainability performance and green economic growth. The utilization of accounting techniques appears to be useful in managing and orienting public policies in the field of renewable energy sources. Challenges derive from the sensitiveness of organizations, as well as in the institutional culture, towards sustainability topics. Thirdly, environmental accounting and environment management accounting and auditing have a role in sustainable development and the sustainable business model by applying measurement techniques (Bicalho et al. 2012; Chan et al. 2014; Gomez-Conde et al. 2019; Näyhä and Horn 2012; Rotzek et al. 2018; Scarpellini et al. 2020). One of the most important methods is life cycle assessment (LCA) to measure evidence and address information supporting decision-making processes. Challenges include the need to collect data and create dedicated standards for environmental accounting systems. Additionally, organizational culture, which can influence the environmental management accounting system and the business model, needs to align with sustainability goals. Finally, this study offers a significant contribution to the literature by exploring the role of accounting and auditing in advancing renewable energy, shifting the focus of academic debate toward a more holistic perspective, i.e. one that goes beyond combating climate change to encompass pressing environmental issues like air pollution. This paper is structured as follows. Section 2 presents the research context and method. Section 3 discusses the results, while Section 4 develops insights and critiques the literature, while also discussing the main implications of the research. Section 5 presents conclusions and identifies opportunities for future research.

2 | The Methods for the Literature Analysis

We adopted the SLR method to examine, advance, and critique the literature and foster new research paths (Asmussen and Møller 2019; Garanina et al. 2022; Petticrew and Roberts 2006; Massaro et al. 2016; Lombardi et al. 2022). The SLR allowed us to validate the analysis of a new research field (Shah and Corley 2006). We defined the research protocol, research questions, and the literature search (i); the study's impact (ii); Identifying the analytical framework, research reliability, and validity in the data coding (iii); determining insights and critique of the literature (iv); and proposing research streams for future research (v) (Garanina et al. 2022; Massaro et al. 2016). We used R and VOSwier software to develop, respectively, the content and bibliometric analysis. We provide below the description of i), ii), and iii) of the research protocol, while the insights and critique, and the future research streams identified are presented in later sections.

2.1 | Defining the Research Protocol and the Literature Search

We defined the opportunities and challenges of accounting, auditing and renewable energy sources using the SLR (Garanina et al. 2022; Petticrew and Roberts 2006; Massaro et al. 2016) and proposed emerging research streams as emerging topics in the international field also in the light of external and contingent

factors. We identified the rationale for the research and how we settled studies (Petticrew and Roberts 2008) in the light of the principles of transparency and replicability (Tranfield et al. 2003). We defined the literature analysis proposing insights, critique, and the emerging research streams for future research in the field of accounting, auditing and renewable energy sources. We retain this topic to be discovered through several perspectives of analysis also in the light of contingent factors inside and outside companies.

We used the 1, 2, 3, 4 and 4* accounting journals ranked by CABS as the main source for this analysis. We assumed to develop the analysis in the last 22 years from 2002 to 2023 since the first publication retrieved in the dataset. We collected 229 main academic articles of which 32 were core articles. Thus, defined the nodes for coding topics using previous milestones (Dumay and Cai 2014) and adjusted them to better develop our analysis (see Table 1): studies and main features; regions of research; research methods; clusters articles' focus.

The literature search and the definition of the dataset are influenced by the recent Scholars' attention posed to the topic of renewable energy sources as well as by the contingent factors. Thus, we collected studies of the accounting journals ranked CABS (1, 2, 3, 4 and 4*) to promptly define our dataset using relevant sources in the field of accounting and auditing. The selection was established in the "accounting" subject. To make our searching efficient, we used Scopus databases using the specific queries containing the ISSN of previous sources. Thus, over the 22 years (2002–2023), we consulted 89 sources of which 14 core sources: journals ranked 2 CABS are the most relevant output for retrieving academic articles in our dataset (i.e. 15 academic articles). Table 2 proposes the CABS ranking of sources and core sources of academic articles in the dataset also about the ranking positioning.

We established the following set of keywords searched in the CABS accounting journals through the Scopus database (Table 2) in relation to accounting and auditing:

- renewable energy source;
- solar;
- wind;
- hydro;
- hydrogen;
- biomass;
- zero-carbon nuclear.

We collected 229 documents selecting articles and review categories through the titles and/or abstracts. We adopted the Boolean operators "AND" and "OR". We screened collected documents assuming previous keywords in the Scopus query, our main topic and aims as matching criteria to further define the boundary of the research. Particularly, all authors read titles, abstracts and keywords independently to establish the relevance of documents without considering additional criteria (e.g. the citations lever), applying a manual text mining method instead of a bibliometric method. After reading and discussing the remaining group of documents for which there

TABLE 1 | Research nodes for the analysis development.

Category	Variables	Results
Studies and main features	Scholars	81
	Scholars' average per academic article	2,61
	Journal	2
	• 1 <i>CABS</i>	15
	• 2 <i>CABS</i>	12
	• 3 <i>CABS</i>	0
	• 4 <i>CABS</i>	2
	• 4* <i>CABS</i>	31
	• <i>Total</i>	
	Affiliation	79
	• University	1
	• Company	1
	• Other types of organizations	
	Year	2002–2022
Regions of research	Overall citations	1682
	North America	4
	Australia	2
	South America	2
	Combination of continent/countries	5
	Europe	3
	Africa	3
	Asia	2
	Not specified	10
	Research methods	Regression
Survey/interview		7
Case study		5
Critic/view point		4
Literature review		3
Content analysis		2
Clusters articles' focus		Sustainability accounting and accounting for renewable energy
	Accounting, institutions and environment	10
	Environmental accounting and management and sustainable development model	9

were doubts in relevance, agreement was reached that 32 documents represented the best selection of academic articles to answer the research questions. Table 3 shows the main criteria adopted in the dataset definition.

Table 4 provides the list of articles composing the dataset. The table shows the 32 core articles selected by the authors. The articles are represented in alphabetic order indicating the authors, the year, the title and the source of the sampled documents. The selection of only 32 articles may stem from the exclusive focus on accounting journals. Nevertheless, there are additional pertinent studies published in journals outside the accounting

domain that could prove relevant insights such as Schaltegger et al. (2024) and Cairns (2004).

2.2 | The Studies' Impact

We collected 32 academic articles also providing the total number of citations and citations per year (CPY). We highlight that the investigated topic is an emerging stream of research. Table 5 provides such metrics analytically along the years after 2018 and in summary before 2018 showing a total number of 2418 citations.

TABLE 2 | Source Title—Accounting Journal CABS.

Sources	Core sources	CABS
Accounting Review	x	4*
Accounting, Organizations and Society		4*
Journal of Accounting and Economics		4*
Journal of Accounting Research	x	4*
Contemporary Accounting Research		4
Review of Accounting Studies		4
Abacus	x	3
Accounting and Business Research		3
Accounting Forum	x	3
Accounting Horizons		3
Accounting, Auditing and Accountability Journal	x	3
Auditing	x	3
Behavioral Research in Accounting		3
British Accounting Review	x	3
British Tax Review		3
Critical Perspectives on Accounting	x	3
European Accounting Review		3
Financial Accountability and Management		3
Foundations and Trends in Accounting		3
International Journal of Accounting		3
Journal of Accounting and Public Policy		3
Journal of Accounting Literature		3
Journal of Accounting, Auditing and Finance		3
Journal of Business Finance and Accounting		3
Journal of International Accounting, Auditing and Taxation		3
Journal of the American Taxation Association		3
Management Accounting Research		3
Accounting and the Public Interest		2
Accounting and Finance	x	2
Accounting in Europe		2
Accounting Research Journal		2
Accounting, Economics and Law: A Convivium		2
Advances in Accounting		2
Advances in accounting Behavioral Research		2
Advances in Management Accounting		2
Advances in Taxation		2
Asia-Pacific Journal of Accounting and Economics		2
Asian Review of Accounting		2

(Continues)

TABLE 2 | (Continued)

Sources	Core sources	CABS
Australian Accounting Review	x	2
China Journal of Accounting Research		2
Current Issues in Auditing		2
International Journal of Accounting and Information Management		2
International Journal of Accounting Information Systems		2
International Journal of Accounting, Auditing and Performance Evaluation		2
International Journal of Auditing		2
International Journal of Disclosure and Governance		2
International Journal of Managerial and Financial Accounting		2
Journal of Accounting and Organizational Change		2
Journal of Accounting in Emerging Economies		2
Journal of Applied Accounting Research		2
Journal of Contemporary Accounting and Economics		2
Journal of International Accounting Research		2
Journal of International Financial Management and Accounting		2
Journal of Management Control		2
Journal of Public Budgeting, Accounting and Financial Management		2
Journal of Tax Administration		2
Managerial Auditing Journal		2
Qualitative Research in Accounting and Management	x	2
Research in Accounting Regulation		2
Sustainability Accounting, Management and Policy Journal	x	2
Accounting, Finance & Governance Review		1
Advances in Environmental Accounting and Management	X	1
Advances in Public Interest Accounting		1
African Journal of Accounting Auditing and Finance		1
Ata Journal of Legal Tax		1
Australasian Accounting, Business and Finance Journal		1
China Journal of Accounting Studies		1
Comptabilite Controle Audit		1
EDPACS		1
International Journal of Critical Accounting		1
Journal of Accounting and Management Information Systems		1
Journal of Accounting and Taxation		1
Journal of Forensic and Investigative Accounting		1
Journal of Forensic Studies in Accounting and Business		1
Journal of Governmental & Non-Profit Accounting		1
Journal of Information Systems		1

(Continues)

TABLE 2 | (Continued)

Sources	Core sources	CABS
Journal of Islamic Accounting and Business Research		1
Management Accounting Frontiers		1
Management Accounting Quarterly		1
Meditari Accountancy Research		1
Pacific Accounting Review		1
Research in Governmental and Non-Profit Accounting		1
Research on Professional Responsibility and Ethics in Accounting		1
Revista de Contabilidad- Spanish Accounting Review		1
Revista Espanola de Financiacion y Contabilidad		1
Social and Environmental Accountability Journal	X	1
South African Journal of Accounting Research		1
World Tax Journal		1

TABLE 3 | Dataset definition—Main criteria.

Main criteria	Dataset definition
Sources	Chartered Association of Business Schools rankings (CABS rankings): 1, 2, 3, 4 and 4* Scopus database as tool to immediately collect documents
Research subject	Accounting
Horizontal time	2002–2023
Documents' typology	Academic articles; Review articles
Keywords	Accounting and auditing in relation to: renewable energy source, solar, wind, hydro, hydrogen, biomass, zero-carbon nuclear
Screening method	Title, abstract, keywords; research focus and aims; text mining

2.3 | Identifying the analytical framework, research reliability and validity

The analytical framework was established through the verification of changes in the research protocol among co-authors assuming the reliability of results. Additionally, we determine results defining internal and external validity of the analysis in the direction of the results' generalization (Massaro et al. 2016; White and McBurney 2012).

Additionally, the internal validity is based on the pattern matching approach and the time-series analysis (Hollweck 2015). We defined the clusters' analysis based on five clusters. We adjusted clusters into three clusters considering the relevance of documents and topics. We also analysed the dataset

to the level of citations. The data coding follows milestones of literature (Dumay and Cai 2014) adjusted to better achieve research aims representing the three streams. The utilization of software for the content and bibliographic analysis fosters the authors' investigation of documents (Massaro et al. 2016, p. 787). Additionally, quantitative analysis allowed for emphasis on research streams.

3 | Developing Insights and Critique of Literature

This section shows the results of our analysis answering research questions 1–3. *RQ1. What is the state of the art for investigating into accounting, auditing and renewable energy sources? RQ2. What is the focus and critique of literature within the accounting, auditing and renewable energy sources? RQ3. What is the future research for the accounting, auditing and renewable energy sources?* We develop insights and critique the studies in order to identify the main features; regions of research; research methods; and documents' focus.

3.1 | Studies and Main Features

The Scholars authoring academic articles in the dataset are 83 and the total average of authors per article is 2.69. We retrieved two documents authored by four scholars; 17 documents authored by three scholars; 12 documents authored by two scholars and one document authored by one scholar. The affiliations of the authors, shown in Figure 1, are: 81 scholars are affiliated with universities; one author is affiliated with a company, and one scholar is involved in another type of organization (i.e. research center).

We screened 89 accounting journals ranked CABS of which 28 sources ranked 1, 34 ranked 2, 21 ranked 3, 2 ranked 4 and 4 ranked 4*. The most prominent accounting journals in the field are Sustainability Accounting, Management and Policy Journal

TABLE 4 | Dataset of documents (alphabetical order).

Authors	Year	Title	Source
Alawattage C., Alsaïd L.A.	2018	Accounting and structural reforms: A case study of Egyptian electricity	Critical Perspectives on Accounting
Asci F., Lovell H.	2011	As frames collide: Making sense of carbon accounting	Accounting, Auditing and Accountability Journal
Bicalho T., Richard J., Bessou C.	2012	Limitations of LCA in environmental accounting for biofuels under RED	Sustainability Accounting, Management and Policy Journal
Brown J., Dillard J.	2014	Integrated reporting: On the need for broadening out and opening up	Accounting, Auditing and Accountability Journal
Bui B., de Villiers C.	2021	Recovery from Covid-19 towards a low-carbon economy: A role for accounting technologies in designing, implementing and assessing stimulus packages	Accounting and Finance
Bunclark L.A., Scott G.J.	2021	Benchmarking corporate water reporting in emerging economies: The case of Peru	Sustainability Accounting, Management and Policy Journal
Burritt R., Schaltegger S.	2012	Measuring the (un-)sustainability of industrial biomass production and use	Sustainability Accounting, Management and Policy Journal
Burritt R.L., Schaltegger S., Zvezdov D.	2011	Carbon Management Accounting: Explaining Practice in Leading German Companies	Australian Accounting Review
Chan H.K., Wang X., Raffoni A.	2014	An integrated approach for green design: Life-cycle, fuzzy AHP and environmental management accounting	British Accounting Review
Chapple L., Clarkson P.M., Gold D.L.	2013	The Cost of Carbon: Capital Market Effects of the Proposed Emission Trading Scheme (ETS)	Abacus
Charnock R., Thomson I.	2019	A Pressing Need to Engage with the Intergovernmental Panel on Climate Change: The Role of SEA Scholars in Syntheses of Social Science Climate Research	Social and Environmental Accountability Journal
Dehaan E., Madsen J., Piotroski J.D.	2017	Do Weather-Induced Moods Affect the Processing of Earnings News?	Australian Accounting Review
Fonseka M., Rajapakse T., Tian G.-L.	2019	The Effects of Environmental Information Disclosure and Energy Types on the Cost of Equity: Evidence from the Energy Industry in China	Abacus
Garcia-Amate A., Ramírez-Orellana A., Rojo Ramirez A.A.	2021	Is it attractive to invest in alternative energy? Evidence from a five-factor Fama–French model for regional DJSI and renewable stock indexes	Sustainability Accounting, Management and Policy Journal

(Continues)

TABLE 4 | (Continued)

Authors	Year	Title	Source
Gomez-Conde J., Lunkes R.J., Rosa F.S.	2019	Environmental innovation practices and operational performance: The joint effects of management accounting and control systems and environmental training	Accounting, Auditing and Accountability Journal
Green W., Li Q.	2012	Evidence of an expectation gap for greenhouse gas emissions assurance	Accounting, Auditing and Accountability Journal
Haque S., Deegan C.	2010	Corporate Climate Change-Related Governance Practices and Related Disclosures: Evidence from Australia	Australian Accounting Review
Hrasky S., Jones M.	2016	Lake Pedder: Accounting, environmental decision-making, nature and impression management	Accounting Forum
Journeault M., Levant Y., Picard C.F.	2021	Sustainability performance reporting: A technocratic shadowing and silencing	Critical Perspectives on Accounting
Jupesta J., Harayama Y., Parayil G.	2011	Sustainable business model for biofuel industries in Indonesia	Sustainability Accounting, Management and Policy Journal
Leotta A., Rizza C., Ruggeri D.	2017	Management accounting and leadership construction in family firms	Qualitative Research in Accounting and Management
Martinov-Bennie N.	2012	Greenhouse gas emissions reporting and assurance: Reflections on the current state	Sustainability Accounting, Management and Policy Journal
Matsumura E.M., Prakash R., Vera-Muñoz S.C.	2014	Firm-value effects of carbon emissions and carbon disclosures	Accounting Review
McBride, K., Sagitova, R., Cam, O.	2023	“As bad as bad can be”: accounting for species extinction in the North Pacific	Accounting, Auditing & Accountability Journal
Moses O., Nnam I.J., Olaniyan J.D., Tariquzzaman A.T.M.	2022	Sustainable Development Goals (SDGs): Assessment of Implementation Progress in Brics And Mint	Advances in Environmental Accounting and Management
Näyhä A., Horn S.	2012	Environmental sustainability—Aspects and criteria in forest biorefineries	Sustainability Accounting, Management and Policy Journal
Rotzek J.N., Scope C., Günther E.	2018	What energy management practice can learn from research on energy culture?	Sustainability Accounting, Management and Policy Journal
Scarpellini S., Marín-Vinuesa L.M., Aranda-Usón A., Portillo-Tarragona P.	2020	Dynamic capabilities and environmental accounting for the circular economy in businesses	Sustainability Accounting, Management and Policy Journal

(Continues)

TABLE 4 | (Continued)

Authors	Year	Title	Source
Schneider T., Andreanus M.	2018	A dam tale: Using institutional logics in a case-study on water rights in the Canadian coastal mountains	Sustainability Accounting, Management and Policy Journal
Sharma D.S., Sharma V.D., Litt B.A.	2018	Environmental responsibility, external assurance, and firm valuation	Auditing
Taşkın D., Vardar G., Okan B.	2020	Does renewable energy promote green economic growth in OECD countries?	Sustainability Accounting, Management and Policy Journal
Tello E., Hazelton J., Cummings L.	2016	Potential users' perceptions of general purpose water accounting reports	Accounting, Auditing and Accountability Journal

TABLE 5 | The studies impact (citations; CPY).

	Years							Total
	>2018	2018	2019	2020	2021	2022	<2023	
Number of academic articles	17	4	3	2	4	1	1	32
Citations	399	147	161	242	302	426	478	2155
Citation per year	0.04	0.03	0.02	0.008	0.013	0.002	0.002	

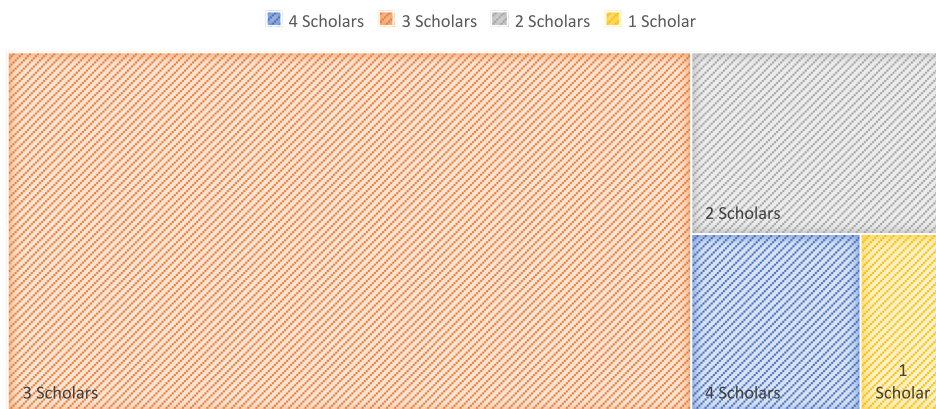


FIGURE 1 | Number of authors.

publishing 11 academic articles and Accounting and Auditing and Accountability Journal publishing 6 academic articles. Table 6 shows the list of the most relevant sources per document and ranking CABS.

The publication of academic articles in the dataset started in 2010 with an average increasing trend of 0.38. Figure 2 shows the trend of publication. The trend has remained stable over the last years even if this is a recent research topic also in the light of external and contingent factors. There is no presence of

significant maximum points. The largest increase occurred between 2010 and 2012 and between 2014 and 2021.

The trend of citation achieved 426 citations in 2022; at the same time, the lowest year of citation is 2018 with 147 citations. The trend of CPY is 54.26. The most cited documents are Matsumura et al. (2014) with 721 citations, Brown and Dillard (2014) with 274 citations and Chapple et al. (2013) with 252 citations. Table 7 shows the top eight academic articles in the dataset per citation and CPY.

TABLE 6 | Sources per documents (alphabetical order).

Source	Numbers of academic articles	CABS
Abacus	2	3
Accounting and Auditing and Accountability Journal	5	3
Accounting and Finance	1	3
Accounting Forum	1	3
Accounting Review	1	4*
Advances in Environmental Accounting and Management	1	1
Auditing	1	3
Australian Accounting Review	2	2
British Accounting Review	1	3
Critical Perspectives on Accounting	2	3
Journal of Accounting Research	1	4*
Qualitative Research in Accounting and Management	1	2
Social and Environmental Accountability Journal	1	1
Sustainability Accounting, Management and Policy Journal	11	2

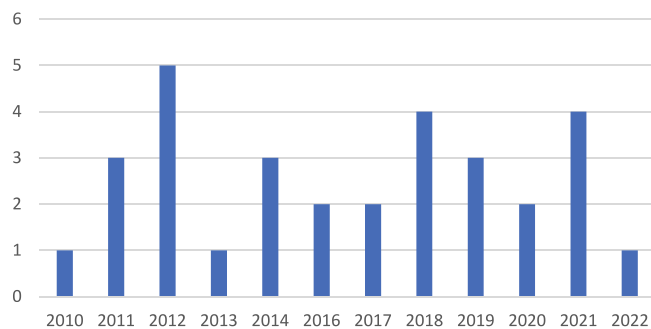


FIGURE 2 | Production over the time.

Figure 3 shows the author's publication production in relation to the year of the article's publication. Thus, the top-authors' production over time reveals that each author published one academic article in the horizontal time; only two authors contributed to the publication of two academic articles.

3.2 | Regions of Research

This section shows the regions of research (or geographical areas) that have been the subject of analysis. Figure 4 provides

evidence of the homogenization between the research contexts investigated. North America is the most investigated context with four articles (about 18%), followed by Europe and Africa (about 14%) and Asia, Australia and South America (about 9%). The presence of six works was also found in which scholars analyzed two or more different contexts. Finally, due to the presence of literature review works or critical insights and points of view, the presence of 10 academic articles that cannot be placed in specific contexts is highlighted.

3.3 | Research Methods

Following the best practices in the literature (Elshandidy et al. 2018; Lombardi et al. 2022), we proceeded to categorize the research methods used in the sample of articles. Most of the research conducted by the scholars used qualitative methodologies, around 68% of the total number of articles. About 22% of the articles were based on interviews or surveys and 16% analyzed case studies. Concerning quantitative studies, they have been used more for comparisons between different contexts. Quantitative studies mainly refer to regressions. The majority of scholars used OLS regressions while the adoption of other models such as the GLS or the five-factor model appeared to be residual. Figure 5 summarizes the types of methods of the sample of articles analysed.

3.4 | Clusters Articles' Focus

We retrieved academic articles' focus adjusting them into relevant clusters. Firstly, we applied the keywords and bibliometric analysis (Van Eck and Waltman 2009, Van Eck and Waltman 2017) assuming five clusters. Figure 6 shows the co-occurrence of keywords and Table 8 presents the top 11 keywords in terms of frequency. However, the importance of spheres in the figure derives from their size and it is based on the degree centrality measure (McCulloh et al. 2013).

Particularly, we propose in Table 9 the clusters of keywords as a result of the co-occurrence analysis.

From the analysis of keywords, we first drafted the following emerging topics:

- i. Sustainability accounting and accounting for alternative energy;
- ii. Environmental accounting and management, sustainable development model and strategic analysis.

Similarly, we analyzed the bibliographic coupling of the documents, retrieving the list of documents per citation (Table 10) and the clusters of documents (Figure 7; Table 11). To determine clusters, we adopted the full counting method, and we defined five clusters concerning the focus of academic articles.

This process of cluster analysis allowed us to identify three main emerging research areas after the adjusted matching of topics among the previous clusters. We identify that the academic articles are clustered into three research streams, as shown in Table 12.

TABLE 7 | Top eight documents.

Authors	Year	Title	Source	Citations	CPY
Matsumura E.M., Prakash R., Vera-Muñoz S.C.	2014	Firm-value effects of carbon emissions and carbon disclosures	Accounting Review	461	57.63
Brown J., Dillard J.	2014	Integrated reporting: On the need for broadening out and opening up	Accounting, Auditing and Accountability Journal	226	28.25
Chapple L., Clarkson P.M., Gold D.L.	2013	The Cost of Carbon: Capital Market Effects of the Proposed Emission Trading Scheme (ETS)	Abacus	159	17.67
Burritt R.L., Schaltegger S., Zvezdov D.	2011	Carbon Management Accounting: Explaining Practice in Leading German Companies	Australian Accounting Review	118	10.73
Ascui F., Lovell H.	2011	As frames collide: Making sense of carbon accounting	Accounting, Auditing and Accountability Journal	108	9.82
Haque S., Deegan C.	2010	Corporate Climate Change-Related Governance Practices and Related Disclosures: Evidence from Australia	Australian Accounting Review	92	7.67
Dehaan E., Madsen J., Piotroski J.D.	2017	Do Weather-Induced Moods Affect the Processing of Earnings News?	Journal of Accounting Research	72	14.4
Scarpellini S., Marin-Vinuesa L.M., Aranda-Uson A., Portillo-Tarragona P.	2020	Dynamic capabilities and environmental accounting for the circular economy in business	Sustainability Accounting, Management and Policy Journal	57	28.5

Top-Authors' Production over the Time

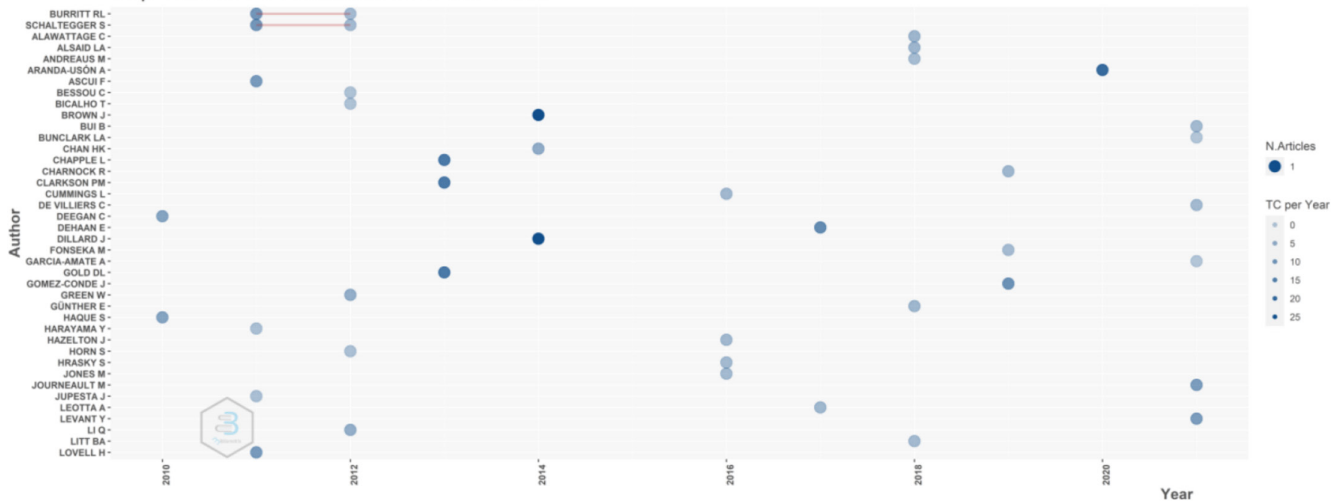


FIGURE 3 | Top-Authors' production.

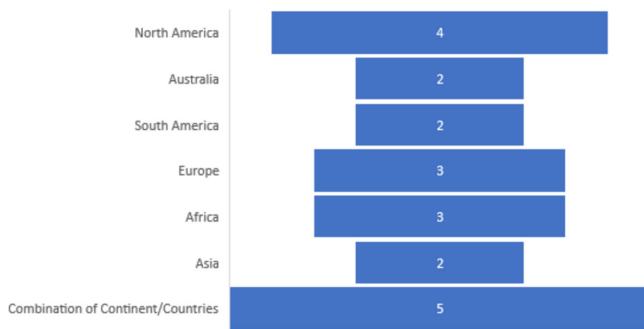


FIGURE 4 | Geographical regions of research.

3.4.1 | Stream of Research 1

The first stream of research is based on sustainability accounting and accounting for renewable energy. This research stream seems the most relevant in the analysis, considering the number of academic articles based on the topics of sustainability accounting and accounting for renewable energy or alternative energy. The authors assumed several perspectives of analysis, including carbon accounting, greenhouse gas emission (GHG) assurance, disclosure practices on climate change corporate governance, and accounting and reporting procedures and assurance methods in the field of renewable energy for zero-carbon results.

Ascui and Lovell (2011) analyze the concept of carbon accounting by assuming the perspectives of scientists, policy negotiators, and market practitioners of the United Nations Clean Development Mechanism and the International Accounting Standards Board. The authors make the interactions between different forms of carbon accounting explicit, assuming it to be an essential factor in addressing climate issues on the planet. Particularly, they argue that “Tensions and contradictions in carbon accounting can be understood as the result of “collisions” between at least five overlapping frames of reference, namely physical, political, market-enabling, financial and social/environmental modes of carbon accounting.” (Ascui and Lovell 2011,

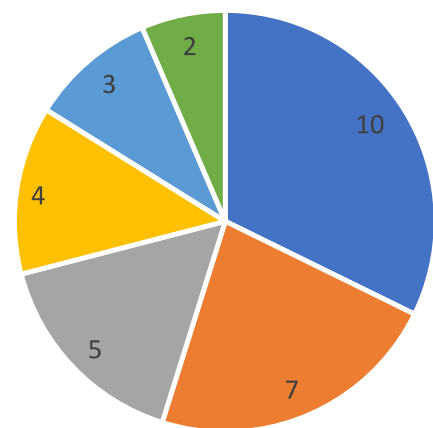


FIGURE 5 | Research method.

p 978). Charnock and Thomson (2019) investigate the climate change issue, emphasizing how low-carbon technological advances are part of the planet’s future. The authors demonstrate that the topic has been prioritized by the Intergovernmental Panel on Climate Change for two decades now, strengthening the academic basis for climate finance policymaking. Green and Li (2012) present an experimental investigation of GHG assurance from the perspectives of three groups of stakeholders: emission preparers, emission assurers, and shareholders. All three groups were surveyed, and an emissions assurance gap in expectation was identified concerning the responsibility of assurers and management and the objectivity of assurers. In this work, all groups examined acknowledged the relevance of the GHG information but did not perceive it as useful for their decision-making processes. However, it is important to consider the year in which the research was conducted, as the reporting

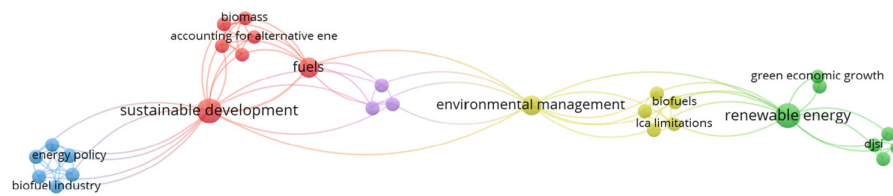


FIGURE 6 | Co-occurrence of all keywords.

TABLE 8 | Top eleven—Occurrences keywords.

Keyword	Occurrences
Renewable energy	3
Sustainable development	3
Environmental management	2
Environmental management accounting	2
Firm value	2
Fuels	2
Global warming	2
Impression management	2
Institutional logics	2
Sustainability	2
Water accounting	2

and assurance practices at that time did not account for recent regulatory changes or the growing attention stakeholders have since placed on these issues.

Haque and Deegan (2010) studied disclosure practices on climate change corporate governance. The authors state that stakeholders ask companies to release public information on their climate change initiatives. Haque and Deegan (2010) examine a sample of energy-intensive Australian companies over 16 years, showing how these companies have practiced corporate governance related to climate change. The level of disclosure practices in the sample was low. Martinov-Bennie (2012) investigates how climate change (i.e., the use of biomass to reduce GHG emissions) affects and changes companies in terms of requiring accounting and reporting procedures and assurance methods. The author highlights how GHG emission reporting and assurance are connected with rigorous governance frameworks and stringent management systems, as well as underlines the relevance of assurance to achieve zero-carbon results. He argues that “*This general need for reporting, independent auditing and assurance is also relevant*

for policies and measures where biomass is introduced in different countries and used to reduce GHG emissions” (Martinov-Bennie 2012, p. 244). The authors also stress the need for more knowledge and cross-functional skills, both in the process and in accounting and assurance.

Burritt and Schaltegger (2012) examine issues related to sustainability accounting or accounting for alternative energy (i.e., sustainability accounting for biomass), proposing the use of accounting to address the unsustainability of production and the use of industrial biomass. They suggest a perspective focused on the importance and issues of biomass production for industrial use and, consequently, of sustainability issues involving three accounting areas: i) “*emissions directly released by the company and recorded in internal company carbon management accounting*”; ii) “*emissions indirectly caused for the generation of purchased electricity*”; iii) “*emissions from suppliers of inputs and downstream emissions from distribution, use and end of product*” (Burritt and Schaltegger 2012, p. 113). The authors argue that “*It discusses possibilities for and limitations of accounting to address these sustainability issues as well as the need for and the challenges in measuring the (un-)sustainability of biomass production for industrial use and the accounting for sustainability improvements.*” (Burritt and Schaltegger 2012, p. 109). Different issues related to the implementation of new systems and the acquisition of new assets that reduce the impact on the environment are analyzed. According to the authors, the accounting of new renewable energies must address issues such as the investments made for plants to transition to the use of alternative energy (e.g., wind and solar); otherwise, the costs of externalities on the environment and society are not recognized.

Fonseka et al. (2019) analyze environmental information disclosure and energy sources in relation to their effects on the cost of equity capital. The authors find a positive relationship “*between some energy sources such as gas, fossil-fueled thermal power generation, and oil and energy firms’ COEC*” (Fonseka et al. 2019, p. 400) and a negative connection between some energy production typologies such as hydro-power generation, solar, and wind and the COEC. Then, they highlighted the role of regulation in the Chinese context, suggesting that it can assist companies in achieving environmental objectives. In their

TABLE 9 | Clusters of keywords.

Clusters of keywords
Cluster 1 (red color): accounting for alternative energy, biomass, economic sustainability, fuels, industrial biomass, sustainability accounting, sustainable development
Cluster 2 (green color): renewable energy, green economy growth, djsi, risk return analysis, socially responsible investments, stock indexes, trade openness
Cluster 3 (blue color): energy policy, biofuel industry, Indonesia, key player, strategic analysis, sustainable business model
Cluster 4 (yellow color): environment management, biofuels, lca limitations, enterprise-specific data, environmental accounting, renewable energy directive
Cluster 5 (violet color): environmental sustainability aspects and criteria, forest biorefineries, raw material availability and sustainability

view, environmental information disclosure “can be used as a tool for pollution control and environmental governance for government authorities.” (Fonseka et al. 2019, p. 402). Matsumura et al. (2014) investigate the carbon disclosure of companies that voluntarily disclose information on carbon emissions and the influence of this on firm value. They also study managers’ decisions in disclosing carbon emissions and the effects on firm value. They argue for the relevance of the voluntary disclosure of carbon emissions to sustain firm valuation. It follows that, given the increasing importance of the environment, companies that do not share this information obtain poor ratings. Specifically for renewable energies, the authors’ results showed that companies that adopt strong green energy policies are incentivized to provide more voluntary information to inform stakeholders of the good practices implemented.

Sharma et al. (2018) present how a company’s external auditors evaluate environmental responsibility initiatives in the auditing of financial statements. The authors also investigate investors’ role in evaluating firms and their environmental initiatives when high audit fees are involved. Brown and Dillard (2014) analyze integrated reporting to broaden the debate on how accounting standards can hinder efforts to promote sustainable business practices. There is a connection between integrated reporting and all social and environmental policies. The adoption of integrated reporting can help companies in organizational and process changes and in identifying opportunities to reduce emissions in favor of clean energy processes. However, the authors argue that the integrated reporting tool should be reassessed to reflect a broader approach to different perspectives.

3.4.2 | Stream of Research 2

The main topic of this stream is related to the relationship between accounting, institutions and environment. Alawattage and Alsaïd (2018) investigate a case study of Egyptian electricity in the field of accounting and structural reforms. The authors show the relationship between accounting and the political relations to which the state is subjected in a given historical period. Thus, accounting can take on political significance when it institutionalizes the reforming ideologies of the state. Bui and De Villiers (2021, p. 4789) highlight how “accounting technologies

can be used to help stimulus packages achieving the twin goals of economic stimulus and climate mitigation”. The authors emphasize how incorporating accounting technologies (e.g., budget documents, auditing, and risk assessment) explicitly can enable economic growth, social equity, and climate crisis resolution. Additionally, they argue that “Carbon management accounting changed to support the new strategy adopted in each time period. Long term physical and monetarized accounts for sustainability and extensive use of carbon information were prevalent during periods when the companies employed a proactive or creative strategy. In contrast, short-term physical accounts for unsustainability and limited use in decision-making were observed when the companies adopted stable, anticipatory or reactive strategies.” (Bui and De Villiers 2021, p. 4). Schneider and Andreus (2018) examine a longitudinal case study in which a Canadian company obtained a perpetual water license (i.e., water rights) for a large area in Northern British Columbia in Canada. They propose that the role of actors over time has changed and that colors with a marginal role have subsequently played important roles. They apply institutional logics in a multiperiod context to verify how dominant actors can constrain a future institutional field.

Hrasky and Jones (2016) highlight how accounting information is a tool to legitimize corporate decision-making that supports cost-benefit calculations. By presenting a case, they analyze environmental decision-making and accounting, stating that “as an impression management tool through selectivity, bias and enhancement. It provides a rare illustration of the limitations of accounting for an infrastructural environmental decision using a real life, in depth case study.” (Hrasky and Jones 2016, pp. 285). Therefore, this case is valuable in pointing out the importance of considering environmental value in project decision-making. Journeault et al. (2021) propose the analysis of the case study of Hydro-Québec to verify how the global reporting initiative (GRI) guidelines “legitimized and reinforced through their institutionalization, tend to create a limited scope and an incomplete picture of the organization’s sustainability performance reporting.” (Journeault et al. 2021, pp. 1). Assuming the technocratic and ontological perspectives from the analysis, the authors contribute “to silencing alternative ontologies in organizational sustainability performance reporting” (Journeault et al. 2021, pp. 1). They also argue that “case demonstrates both the selectivity and biased nature of traditional accounting and its limitations

TABLE 10 | Bibliographic coupling per documents.

Academic articles	Citations
Matsumura et al. (2014)	447
Brown and Dillard (2014)	223
Chapple et al. (2013)	157
Burritt et al. (2011)	118
Haque and Deegan (2010)	92
Dehaan et al. (2017)	71
Green and Li (2012)	54
Scarpellini et al. (2020)	52
Chan et al. (2014)	47
Gomez-Conde et al. (2019)	42
Burritt and Schaltegger (2012)	26
Journeault et al. (2021)	17
Leotta et al. (2017)	17
Hrasky and Jones (2016)	17
Tello et al. (2016)	17
Martinov-Bennie (2012)	16
Jupesta et al. (2011)	16
Rotzek et al. (2018)	15
Alawattage and Alsaïd (2018)	15
Näyhä and Horn (2012)	13
Taşkın et al. (2020)	11
Charnock and Thomson (2019)	11
Sharma et al. (2018)	11
Fonseka et al. (2019)	9
Schneider and Andreaus (2018)	9
Bicalho et al. (2012)	9
Bui and De Villiers (2021)	5
Moses et al. (2022)	1

in dealing with environmental issues” (Journeault et al. 2021, pp. 12). In defining major environmental infrastructure works, the authors highlight that “there needs to be full disclosure of accounting for costs and revenues, so that the ultimate decision is seen to be transparent” (Journeault et al. 2021, pp. 13). Then, the authors focus on the transparency of sustainability decisions in relation to underlying accounting practices, highlighting how standards tend to prioritize certain economic and measurable aspects over social ones. This approach can create obstacles to the sustainable development of companies, especially when it is more focused on compliance with standards.

Tello et al. (2016) examine a case and demonstrate both the selectivity and the biased nature of traditional accounting and its limitations in dealing with environmental issues. The authors

assume an accountability perspective by water managers and contribute to emerging studies on general purpose water accounting (GPWA). As argued by the authors, this model (e.g., GPWA) can be expanded also to the other typology of natural resources. Furthermore, an important aspect that emerges from this study is the role of accounting in natural resource environments.

Taşkın et al. (2020) use panel cointegration tests to study the relationship between renewable energy consumption and green economic growth. They also identify the impact of trade openness on member countries of the Organisation for Economic Cooperation and Development. The authors argue that “renewable energy consumption and trade openness exert positive effects on green economic growth. The results of long-run estimates of green economic growth reveal that the long-run elasticity of green economic growth for trade openness is much greater than for renewable energy consumption.” (Taşkın et al. 2020, p. 787). and state that, in addition to reducing carbon emissions, implementing renewable energy-oriented public policies is also crucial to reduce “reduce excessive economic burden arising from foreign energy sources, volatile energy prices on international markets and curtail environmental degradation related with carbon emissions.” (Taşkın et al. 2020, pp. 789).

3.4.3 | Stream of Research 3

This stream of research is based on the environmental accounting and management and sustainable development model. Bicalho et al. (2012) analyze the limits of biofuel LCA in environmental accounting following the Renewable Energy Directive (RED). One limitation of LCA as a decision support tool is the lack of data and standards from environmental accounting systems. The authors underline that “systematic accounting and auditing has been developed to manage the conservation of financial capital successfully, this is not yet the case for the conservation of natural capital” (Bicalho et al. 2012, p. 227). This limitation can be reduced by establishing an environmental accounting system and making RED effective. The authors argue that entities interested in promoting the use of sustainable resources, such as the European Union, will guide the process leading to the standardization and regulation of environmental accounting.

McBride et al. (2023) explore the link between ecology and accounting, stressing the growing environmental awareness over the years and the role of accounting in managing ecological issues. Analyzing the reports of the Russian-American Company, they demonstrate how the firm has successfully integrated corporate reporting with the management of endangered species, achieving significant results in conserving natural resources. They also propose the adoption of emancipatory accounting as a tool to promote the sustainable management of natural resources and to achieve transparency in business operations, providing an innovative approach to addressing environmental challenges. The authors provide empirical evidence of the development of frameworks and models for sustainable management, offering valuable insights into the practical application of concepts, such as extinction accounting and species conservation.

Chan et al. (2014) propose an integrated approach for modern businesses when measuring environmental and organizational

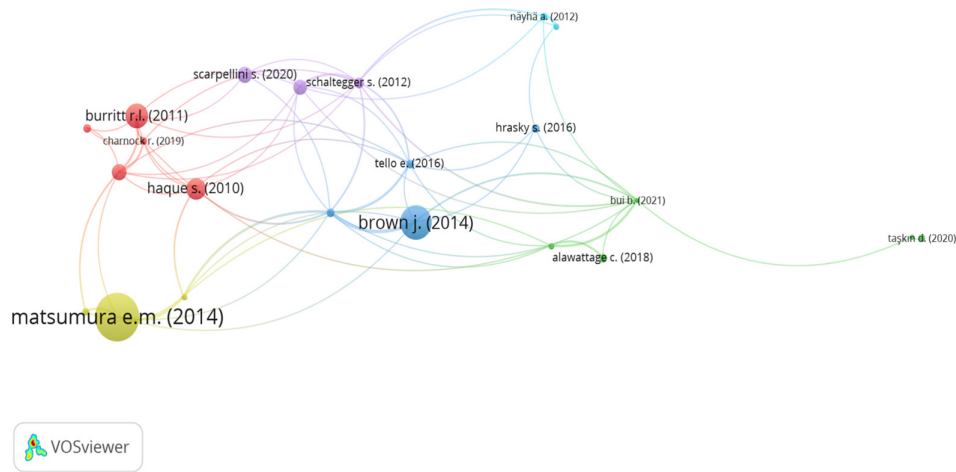


FIGURE 7 | Bibliographic coupling per documents.

TABLE 11 | Bibliographic clustering of documents.

Cluster	Authors
Cluster 1 (red)	Ascuí and Lovell (2011) Charnock and Thomson (2019) Green and Li (2012) Haque and Deegan (2010) Martinov-Bennie (2012) Burrirtt and Schaltegger (2012)
Cluster 2 (green)	Chan et al. (2014) Gomez-Conde et al. (2019) Rotzek et al. (2018) Scarpellini et al. (2020)
Cluster 3 (blue)	Alawattage and Alsaid (2018) Bui and De Villiers (2021) Schneider and Andreaus (2018) Taşkın et al. (2020)
Cluster 4 (yellow)	Brown and Dillard (2014) Hrasky and Jones (2016) Journeault et al. (2021) Tello et al. (2016)
Cluster 5 (violet)	Fonseka et al. (2019) Matsumura et al. (2014) Sharma et al. (2018)

performance. Particularly, the authors base the approach on LCA, environmental management accounting, fuzzy logic, and the analytical hierarchical process. They argue that “*The measurement approach presented in this research can help companies reduce development lead time by screening out undesirable design options. More importantly, the approach can be modelled with the use of an Excel spreadsheet, which means limited resources are needed to implement the proposed method*” (Chan et al. 2014, p. 345). They develop a model that enables the evaluation of product proposals that are more environmentally friendly and better aligned with stakeholder expectations, highlighting the best options while significantly saving time. This model also aids in the

development of sustainability accounting within the company, with a stronger focus on green aspects.

Gomez-Conde et al. (2019) investigate the joint effects of management accounting and control systems (MACS) and environmental innovation practices and operational performance in sustainable development. The authors present that “*the monitoring role of MACS (i.e. diagnostic use) combined with environmental training improves the effect of environmental innovation practices on operational performance.*” (Gomez-Conde et al. 2019, p. 1325). The results of their study emphasize the significant impact that implementing environmental innovation practices has on operational performance.

Rotzek et al. (2018) propose a systematic review of energy management research, identifying a gap between academic methods and industrial needs and refining an energy culture framework based on barriers and drivers. Their article supports future research in the field of sustainability management accounting. Among other ideas, the authors argue that integrating “*within sustainability management accounting or EMA along management control systems could help to better understand the control of energy cultures*” (Rotzek et al. 2018, p. 541). Scarpellini et al. (2020) investigate businesses’ dynamic capabilities and environmental accounting for a circular economy. The authors attempt to measure how environmental capabilities (also retrieved in certification standards, such as ISO14001 and ISO14006) are applied when a circular economy is introduced in a company. The circular economy is a model that favors the transition to renewable resources. The results suggest a positive relationship between companies’ circular economy, environmental accounting, and accountability practices. The authors challenge an approach that seeks to overcome “*conventional accounting approaches and incorporates a much broader scale of environmental information that can be applied to CE practices*” (Scarpellini et al. 2020, pp. 1148). Näyhä and Horn (2012) analyze environmental sustainability in terms of aspects and criteria in forest biorefineries. The authors apply the interview method with representatives of the forestry and bioproduct sectors in Scandinavia and North America. They highlight the most significant aspects of and criteria for environmental sustainability in the forest biorefinery sector.

TABLE 12 | Clustering of documents per stream of research.

Stream of research	Authors	Years	Title	Citations
STREAM OF RESEARCH 1: Sustainability accounting and accounting for alternative energy	Ascui, Lovell	2011	As frames collide: Making sense of carbon accounting	105
	Fonseka et al.	2019	The Effects of Environmental Information Disclosure and Energy Types on the Cost of Equity: Evidence from the Energy Industry in China	9
	Matsumura et al.	2014	Firm-value effects of carbon emissions and carbon disclosures	447
	Charnock, Thomson	2019	A Pressing Need to Engage with the Intergovernmental Panel on Climate Change: The Role of SEA Scholars in Syntheses of Social Science Climate Research	11
	Sharma et al.	2018	Environmental responsibility, external assurance, and firm valuation	11
	Green, Li	2012	Evidence of an expectation gap for greenhouse gas emissions assurance	54
	Haque, Deegan	2010	Corporate Climate Change-Related Governance Practices and Related Disclosures: Evidence from Australia	92
	Martinov-Bennie	2012	Greenhouse gas emissions reporting and assurance: Reflections on the current state	16
	Brown, Dillard	2014	Integrated reporting: On the need for broadening out and opening up	226
	Burritt, Schaltegger	2012	Measuring the (un-)sustainability of industrial biomass production and use	26

(Continues)

TABLE 12 | (Continued)

Stream of research	Authors	Years	Title	Citations
STREAM OF RESEARCH 2: Accounting, Institutions and Environment	Alawattage, Alsaïd	2018	Accounting and structural reforms: A case study of Egyptian electricity	15
	Bui, de Villiers	2021	Recovery from Covid-19 towards a low-carbon economy: A role for accounting technologies in designing, implementing and assessing stimulus packages	5
	Hrasky, Jones	2016	Lake Pedder: Accounting, environmental decision-making, nature and impression management	17
	Journeault et al.	2021	Sustainability performance reporting: A technocratic shadowing and silencing	17
	Schneider, Andreus	2018	A dam tale: Using institutional logics in a case-study on water rights in the Canadian coastal mountains	9
STREAM OF RESEARCH 3: Environmental accounting and management and sustainable development model	Taşkın et al.	2020	Does renewable energy promote green economic growth in OECD countries?	11
	Tello et al.	2016	Potential users' perceptions of general purpose water accounting reports	17
	Bicalho et al.	2012	Limitations of LCA in environmental accounting for biofuels under RED	8
	Chan et al.	2014	An integrated approach for green design: Life-cycle, fuzzy AHP and environmental management accounting	47
	Gomez-Conde et al.	2019	Environmental innovation practices and operational performance: The joint effects of management accounting and control systems and environmental training	42
	Rotzek et al.	2018	What energy management practice can learn from research on energy culture?	15
	Scarpellini et al.	2020	Dynamic capabilities and environmental accounting for the circular economy in businesses	52
	Näyhä and Horn	2012	Environmental sustainability—Aspects and criteria in forest biorefineries	13

4 | Theoretical and Practical Implications: Opportunities and Challenges of the Research

This section presents a critical analysis and discussion of the debates and controversies identified from the academic articles reviewed (Alvesson and Deetz 2000), answering RQ3 and proposing the transformative redefinition of evidence. In particular, we define the opportunities and challenges of research in this field and identify the main implications.

4.1 | Implication 1—The Accounting and Auditing for Renewable Energy or Alternative Energy is a Prominent Research Topic for Academic and Relevant Issues for Practitioners and Decision-Makers

The analyses in previous studies show the application of sustainability accounting and auditing for renewable energy, alternative energy, or natural resources and their relevance in recent years (Ascui and Lovell 2011; Brown and Dillard 2014; Charnock and Thomson 2019; Fonseka et al. 2019; Green and Li 2012; Haque and Deegan 2010; Martinov-Bennie 2012; Matsumura et al. 2014; Sharma et al. 2018; Burritt and Schaltegger 2012). This is an emerging stream of research offering opportunities for planning, executing, and guiding corporate behaviors and decision-making in the field of renewable energy sources through accounting and auditing tools, and is also geared toward reducing GHG emissions. First, accounting and auditing for renewable energy sources aim to provide ad hoc tools and methods of measurement, reporting, disclosure, auditing, and assurance to address alternative energy issues at the corporate level: *“One strong system for monitoring, controlling and mitigating bad behaviours is accounting. Hence, accounting for the natural resources used for energy purposes is an area in critical need of research.”* (Burritt and Schaltegger 2012, pp. 110–111). The establishment of accounting systems for renewable energy (e.g., carbon accounting and biomass or GHG emission accounting) is useful for academics, practitioners, and decision-makers in measuring and reporting on sustainability topics or when engaging in strategic decision-making using information on, for example, renewable energy sources, biomass, and fuels.

In the same way, the accounting system for natural resources allows for the assessment, control, reporting, and disclosure of sustainability performance through the development of dedicated targets and indicators. Opportunities for renewable energy accounting and sustainability accounting should be further discovered in order to apply accounting and auditing principles and systems to companies' operations. Opportunities could also be derived from the establishment of dedicated standards and principles for the accounting and auditing of renewable energy; this is an emerging topic aligned with both external factors (e.g., management of biomass, climate change, and water management) and contingent factors (e.g., scarcity of traditional energy, pollution, climate change, and geopolitical tensions at the international level). Alternatively, accounting standards could be intended as levers of environmental practices (Brown and Dillard 2014). Increasing reporting and disclosure activities, as well as

auditing and assurance activities, is directed toward improving transparency and accountability toward stakeholders; this has the potential to enhance firm value effects and reduce GHG emissions (Martinov-Bennie 2012).

Companies also voluntarily disclose good practices implemented in the field of accounting for renewable energy sources. Even in earlier years, sustainability accounting has been used as a tool for promoting property, plant, and equipment changes using renewable energy (e.g., solar and water). Activities in the field of accounting for renewable energy are included in the balance sheet and audited to assure stakeholders of the corporate results.

Nevertheless, multiple challenges are involved in accounting for renewable energy sources. First, long-term historical academic evidence of renewable energy accounting systems is lacking, as relevant studies in the field began only in 2010. Second, alternative energy sources should be investigated in relation to their supply chains in order to determine profit and expenditures. In this way, the separation of financial results or performance improvements and renewable resource results is ensured while their integration into companies is ongoing. However, the production chain of renewable energy needs to be defined, and the cost of production needs to be determined in light of transformational activities (e.g., from chemical transformation to transportation and industrial utilization). Finally, human resources, such as accounting staff and auditors, need to improve their knowledge in the field of renewable energy sources in order to manage tools and models in accounting and alternative energy auditing.

4.2 | Implication 2—The Accounting Techniques as Political Tool to Improve Sustainability Performance and Green Economic Growth

Accounting techniques tailored to renewable energy sources offer several opportunities for sustainable performance and green economic growth at the organizational and institutional levels. On one hand, many studies have focused on the sustainability accounting technologies used in companies; on the other hand, few studies have focused *“on how accounting technologies help realise sustainability goals at the governmental/national level. Furthermore, there are increasing calls for exploring the role played by accounting technologies in enabling and furthering a new sustainability agenda, such as pursuing the Sustainable Development Goals (SDGs) (Bebbington and Unerman 2018). Yet it is unclear whether accounting technologies can help governments produce an appropriate budgetary response to the consequences of climate change.”* (Bui and De Villiers 2021, pp. 4791–4792). Thus, academic debate can focus on the use of accounting technologies by governments to monitor and assess progress toward achieving the Sustainable Development Goals, particularly those related to clean energy, reducing GHGs, and combating climate change.

The utilization of accounting techniques as artifacts seems useful in managing and orienting public policies in the field of renewable energy sources, such as energy prices and foreign energy sources (Taşkın et al. 2020) as well as in reforming ideologies (Alawattage and Alsaïd 2018). In this way, *“The production and usage of renewable energy has become inevitable*

for most countries for four main reasons. First, the continued use of nonrenewable energy has implicit costs ... Second, energy security is an important issue for energy importing countries ... Third, imported oil involves high price volatility, which constitutes another form of risk, while the production of renewable energy has the potential to mitigate energy poverty and lead to a sustainable development, especially for emerging countries.” (Taşkın et al. 2020, pp. 772). Furthermore, according to Schaltegger et al. (2024), independence from fossil fuels frees societies from energy dependency and allows for the implementation of accounting techniques aimed at monitoring and improving sustainability performance. These techniques can include carbon accounting and measuring the environmental impact of business activities.

Accounting techniques can be useful for promoting economic growth and social equity, addressing the climate crisis (Bui and De Villiers 2021) and legitimizing environmental corporate decision-making (Hrasky and Jones 2016; Journeault et al. 2021). Through public policy and fiscal incentives, governments can promote the widespread adoption of renewable energy. These initiatives can be in several forms, such as measurement tools, budget systems, risk assessment, and auditing activities: “Accounting technologies refer firstly to artifacts, including accounting measurements, stimulus budget documents, risk assessment matrices, and reports, and secondly to processes such as budget allocation, auditing, internal and external reporting”. (Bui and De Villiers 2021, p. 4791). Thus, opportunities for developing accounting techniques emerge amid the increasing awareness of decision-making regarding renewable energy sources by implementing the use of dedicated tools and methods. These can also be used by organizations and institutions to improve their sustainability performance, along with efforts to increase their legitimization toward stakeholders. Finally, such tools and methods can be used in the configuration of integrated accounting techniques to improve access to and the management of critical resources, fostering efficient processes and positive results. These approaches allow for efficient cost-benefit calculations to be made.

The sensitivity of organizations and the institutional culture toward sustainability topics are known challenges in this field. The theoretical and operational implementation of new sustainability accounting techniques in organizations and institutions is a crucial step that can benefit human resources and existing tools, such as accounting software. Policymakers need to choose the best accounting techniques when engaging in strategic decision-making to achieve sustainable performance and green economic growth. This is an issue involving all divisions and human resources at the institutional level, as well as affecting the awareness of and culture involving renewable energy sources. In this way, the adoption of policies to promote renewable energy can have a significant economic and social impact, including the creation of new positions in the renewable energy sector, the reduction of social inequalities, and the promotion of sustainable communities. Governments can play a key role in raising public awareness and promoting a culture of sustainability, encouraging behavior and choices that reduce environmental impact, and promoting the adoption of sustainable practices. Furthermore, through the decentralization of energy via renewable sources, the power dynamics

between large energy companies and small producers are altered, and accounting techniques can be employed as political tools to monitor and improve sustainability performance, promote transparency and equity in the energy market, and support green economic growth by encouraging the participation of local communities and small businesses (Schaltegger et al. 2024). Additionally, as the nature of renewable energy sources sometimes makes them evasive of financial measurement, policymakers need to adopt nonfinancial measurement: “accounting has a narrow remit. For example, while traditional accounting can capture and measure financial numbers, it fails to account for natural assets. Thus, flora, fauna, ecosystems and natural beauty have no monetary value in traditional accounting terms. They are not, therefore, included in the balance sheet.” (Hrasky and Jones 2016, p. 1).

4.3 | Implication 3—The Role of Environmental Accounting and Environment Management Accounting and Auditing in Fostering Sustainable Development and Sustainable Business Model

Environmental accounting and environmental management accounting and auditing have a role in sustainable development—they help foster a sustainable business model (Bicalho et al. 2012; Chan et al. 2014; Gomez-Conde et al. 2019; McBride et al. 2023; Näyhä and Horn 2012; Rotzek et al. 2018; Scarpellini et al. 2020). In this scenario, environmental management accounting “has recently been proposed as a relevant tool to inform environmental management processes. Within the wider sustainability accounting domain, EMA provides both financial and non-financial information that can help companies improve their environmental and economic performance.” (Chan et al. 2014, p. 3). It is based on measurement techniques that play a role in the assessment of the impacts and results of renewable energy sources.

The LCA method is one of the environmental accounting tools used in environmental management accounting to measure evidence and address information supporting decision-making processes. It allows for the definition, assessment, and reporting of data on corporate environmental impacts as a stand-alone tool or in conjunction with other tools, such as cost analysis (Bicalho et al. 2012, p. 220). Therefore, the development of an integrated approach for the measurement of financial and environmental performance is connected with the implementation of management accounting systems and performance measurement, as well as with assuming the control systems of energy cultures. Additionally, environmental management accounting systems are dependent on management capabilities to meet corporate certification standards, such as ISO 14001, EMAS, ISO 50001, and ISO 14006.

Opportunities for companies also abound by adopting environmental management accounting systems via renewed awareness originating from knowledge of external and contingent factors, such as climate change, energy prices, geopolitical conflicts, and pandemics, thereby influencing economies, organizations, and societies. Additionally, the application of indicators and metrics and the use of Excel spreadsheets can facilitate fast measurement in environmental management accounting

and thus help achieve sustainable development and sustainable business models. The utilization of management accounting control systems assists management in decision-making through innovative models. Furthermore, the integration of environmental concerns into accounting practices can lead to successful conservation efforts and the sustainable management of natural resources within businesses. Indeed, the adoption of emancipatory accounting principles may enhance transparency in business operations and contribute to effectively addressing environmental challenges.

The challenges to environmental management accounting in sustainable business models are mainly related to the need to collect data and create dedicated standards in environmental accounting systems. The utilization of methods such as LCA has several criticisms, such as: “*Criticism of LCA is almost completely limited to the technical LCA literature and is undertaken from several perspectives such as the different methodological choices involved, uncertainties in describing the real world, etc. (Finnveden, 2000).*” (Bicalho et al. 2012, p. 220). Thus, the need for assessment tools has emerged. The limitations of LCA are derived from functional units, spatial and dimensions, and the allocation and estimation of the environmental impact involved (Bicalho et al. 2012). The organizational culture can also influence the environmental management accounting system and the business model. Thus, investment in environmental training is useful in developing a culture for environmental management accounting.

5 | Conclusions and Future Research Agenda

Our SLR analysis aimed to identify opportunities and challenges related to accounting, auditing, and renewable energy sources in order to determine trends and research streams and to develop an agenda for future research. We contribute to the literature (Burritt and Schaltegger 2012; Liesen et al. 2015; O’Dwyer and Unerman 2020; Maama and Appiah 2019) on the role of accounting and auditing for renewable energy. The main findings of our research derive from the analysis of 229 academic articles in the last 22 years particularly the interpretation and critique of 32 academic articles. According to our analysis, the state of the art can be defined through three emerging research streams. The first stream of research seems the most relevant due to the number of academic articles (10) that participate in the topic of sustainability accounting and accounting for renewable energy in which scholars assumed several perspectives of analysis, among which carbon accounting, assurance of GHG, climate change corporate governance disclosure practices, and accounting, reporting, procedures and assurance methods in the field of renewable energy for a zero-carbon future. The second stream of research is related to the relationship between accounting, institutions and the environment showing that accounting techniques can stimulate economic growth and address the climate crisis. The third stream of research is based on the environmental accounting and management and sustainable development model proposing some tools among, which is the application of LCA.

The main implications of our analysis can be described in the form of opportunities and challenges. First, there is growing interest in accounting and auditing for renewable energy, both

in academia and among practitioners and decision-makers (Ascuí and Lovell 2011; Brown and Dillard 2014; Charnock and Thomson 2019; Fonseka et al. 2019; Green and Li 2012; Haque and Deegan 2010; Martinov-Bennie 2012, Matsumura et al. 2014; Sharma et al. 2018; Burritt and Schaltegger 2012). This emerging field offers opportunities, such as the development of measurement tools, reporting and disclosure methods, and auditing practices tailored to alternative energy issues. However, challenges remain in defining and addressing issues, such as financial reporting from renewable resources, understanding the renewable energy production chain, assessing production costs amid transformative activities, and ensuring the expertise of accounting professionals and auditors in renewable energy.

Second, accounting techniques can be instrumental in promoting sustainability performance and green economic growth, particularly through policymaking. These techniques offer opportunities for organizational and institutional sustainability; however, challenges arise from organizational sensitivities and cultural attitudes toward sustainability topics, as well as the need for the effective implementation and utilization of new sustainability accounting techniques. The theoretical and operational implementation of new sustainability accounting techniques is a crucial step for interesting human resources, divisions, and existing tools.

Third, environmental accounting and environmental management accounting and auditing play a role in the sustainable development and sustainable business model by applying measurement techniques, such as LCA, to inform decision-making processes (Bicalho et al. 2012; Chan et al. 2014; Gomez-Conde et al. 2019; McBride et al. 2023; Näyhä and Horn 2012; Rotzek et al. 2018; Scarpellini et al. 2020). Integrated approaches to measuring financial and environmental performance are key, requiring the implementation of management accounting systems and management capabilities. Companies can benefit from renewed awareness driven by external and contingent factors, the application of indicators and metrics, and the utilization of management accounting control systems. The challenges involved are data collection, the development of dedicated standards in environmental accounting, and the influence of the organizational culture on environmental management accounting systems and business models.

The limitations of this study come primarily from the utilization of a primary dataset from the CABS ranking in the field of accounting. A broad set of journals could potentially be used. However, the CABS list provides a form of quality assessment that we consider appropriate for a first study of this nature. Future research could include two or more sources to collect academic articles. Moreover, the analysis we conducted was an initial step and did not encompass the full range of available studies, as only one database was used for document collection. Thus, it provides a foundation for future research. Subsequent studies could explore additional keywords to broaden the analysis in the fields of renewable energy and accounting. Finally, the collected evidence can be enhanced and validated through the application of additional methodologies, such as case studies and quantitative analyses. Future research could also examine further the research questions derived from previous research streams and the implications identified:

<p>Research stream 1 Sustainability accounting and accounting for renewable energy</p>	<p>1.1 What is the state of the art in the accounting and auditing for renewable energy or alternative energy? 1.2 What are strength and weaknesses of the accounting systems alternative energy-based (e.g. accounting for biomass, carbon accounting)? 1.3 How are reporting and disclosure of the accounting for renewable energy? 1.4 What are indicators and standards in the accounting for renewable energy? 1.5 What is the impact of the production chain in accounting for renewable energy? 1.6 Why does the cost of production of renewable energy occur in transformational activities?</p>
<p>Research stream 2 Accounting, Institutions and Environment</p>	<p>2.1 What is the state of the art in accounting, institutions and environment? 2.2 What is the role of accounting for renewable energy in organizations and institutions? 2.3 Is there a connection between sustainability accounting and green economic growth? 2.4 What are new sustainability accounting techniques? 2.5 Does artifacts are directed to manage and orient public policies? 2.6 What is the role of institutional culture towards sustainability topics?</p>
<p>Research stream 3 Environmental accounting and management and sustainable development model</p>	<p>3.1 What are the most diffused accounting techniques in the field of environment management accounting and auditing? 3.2 How is the environmental management accounting system? 3.3 Is the LCA method the best way to measure evidence, and address information supporting decision-making processes? 3.4 What is the integrated approach to measuring financial and environmental performance? 3.5 What is the connection between external and contingent factors and environment management accounting systems and sustainable development models? 3.6 What are environmental capabilities and what is their role in environmental accounting and management? 3.7 What are best practices and evidence in the field? What are data and what is the state of the art in standards in environmental accounting systems?</p>

Future studies could answer the previous groups of research questions. They aim to contribute specifically to the three streams of research and propose evidence and new forthcoming implications enriching literature on this emerging topic.

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