International Journal of Religion
2024
Volume: 5| Number 7 | pp. 379 – 390
ISSN: 2633-352X (Print) | ISSN: 2633-3538 (Online)
ijor.co.uk
DOI: https://doi.org/10.61707/6zrmry88

Environmental Accounting and Sustainability: Bibliometric Analysis and Documentary Review of Scientific Production, Period 2015-2024

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Abstract

The purpose was to describe global scientific and literary outputs, on different aspects around environmental accounting (EA) and sustainability in environmental, business and policy domains, between 2015 and 2024. This was achieved through a quantitative characterization of publications. The methodology used took as referent aspects for the analysis: focus, units, topics, country, authorship, citations and journals, these a descriptive and reflexive documentary study of the scientific literature, based on the collection of papers in Scopus and the use of VOSviewer. The materials were selected according to various criteria, including keywords such as "environmental accounting" and "sustainability", limited to fields such as: business, management and accounting, during the period from 2015 to 2024. The result included the identification of 54 texts, with the years with the highest number of publications being 2015 with 25.8% and 2018 with 19.7% of the total number of documents. Regarding the approaches, a predominant orientation towards the qualitative paradigm was observed, with 70%, compared to the quantitative one, with 32%. The most common types were exploratory (65%), descriptive (20%) and correlational (3%). As for the units, the majority focused on inquiries in companies with 52%, divided between large companies (57%) and MSMEs (11%). In turn, the sectors most frequently observed were tertiary (48%), followed by secondary (34%) and primary (2%). The origin of most of the studies was the United States, the United Kingdom, Australia and Italy. Finally, the limitations found were mainly related to the methodological approach, the inclusion of only one database, which could have excluded relevant studies not indexed in this one.

Keywords: *Environmental Accounting, Generalised Sustainability, Sustainable Development*

INTRODUCTION

One of the imminent effects of the expansion of industries and large corporations globally is the affectation of environmental conditions and the negative impact on natural environments (Jahanshi &Berm, 2018; Zhou et al., 2018). Excessive depletion of natural environments, accumulation of waste and release of greenhouse gases are consequences of human activity. The physical exchange between society and the natural environment, along with the accompanying production and consumption processes, is what social metabolism is all about. This information is crucial to promote methods that use resources more sustainably (Phu et al., 2020). The economic definition of commodity flow is a mechanism that changes the material stocks of the economic system, supplies a constant set of input materials to national economies, and then begins to incorporate these materials into other economies and environments. This underlines the critical importance of finding better ways to account for "natural resources".

In view of this, companies and their different leaderships have oriented their actions towards sustainable development, as the goal of any company that intends to maintain itself and promote balanced development (Dahash & Abdlamer, 2022). In response, management tools have emerged that offer options to give meaning to actions to provide solutions in companies. This is the case of environmental accounting for business, which

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is globally driven by the need to respond to growing environmental awareness and meet the visions formulated by stakeholders, as well as by business opportunities and corporate social responsibility.

Therefore, the definition of environmental accounting, together with the notion of sustainability are fundamental in contemporary business management, which have become increasingly relevant because of the genuine concern for the environmental and social impact of business activities. When inquiring about environmental accounting, it requires a structure that allows for the collection, analysis and presentation of financial and non-financial information related to the environmental aspects of an organisation (Ceballos-Rincón et al., 2022). This includes the measurement of natural resources used, waste generated, pollutant emissions, as well as costs associated with the mitigation of environmental impacts and compliance with environmental regulations. This concept allows companies to assess their environmental performance, recognise areas for improvement and provide comprehensive information that makes it possible to make decisions in order to reduce their ecological footprint.

On the other hand, sustainability is a broader aspect and in the field of business it is interpreted as the ability of an organisation to operate profitably and ethically in the long term, without compromising natural or social resources for future generations. This implies not only minimising unfavourable effects on the environment and consequently on society, but also actively contributing to the well-being of local communities and the conservation of ecosystems (Jiao et al., 2023). Business sustainability encompasses economic, environmental and social aspects and requires an integrated approach in all areas of business, from the supply chain to daily operations and investment strategies.

In relation to environmental accounting as a tool to help companies track their environmental impact, covering metrics such as energy efficiency, natural resource use, waste management and carbon footprint. Environmental sustainability, on the other hand, is the ability to maintain the availability of natural and environmental resources over time without changing their characteristics, which helps to solve the basic challenges of humanity (Zhou et al., 2018; Galárraga, 2023).

As such, its contribution to environmental sustainability has to do with long-term plans that are formulated based not only on production, but also on how the environment receives it, as it helps leadership and others to make decisions based on an awareness of the value of sustainability and minimising the negative effect on the environment. It can also help reduce costs by revealing where a company's image can be improved, which in turn increases the confidence of customers and other stakeholders. This is because it is based on measuring a country's environmental sustainability, which requires monitoring and evaluating how companies in the productive sector use their natural and environmental resources (Castelo et al., 2024).

According to Fuentes et al. (2022), in order to assess the organisation's financial performance and environmental performance or impacts, it is necessary to examine the accounting records. These records, which combine economic facts with an environmental rationale, give indications of the company's environmental management. As awareness of the negative effects that economic activities have on society and the environment increases, environmental accounting and sustainability have become important issues in modern business management. Consequently, assessing and improving the environmental performance of companies now requires the use of sustainability-oriented accounting procedures.

In this article, we conducted a bibliometric analysis and a comprehensive literature review of publications on environmental accounting and sustainability in the period between 2015 and 2024. Through this study, we sought to identify the most relevant trends, approaches and areas of research in this field over the last decade, with the aim of contributing to academic knowledge and offering insights for future research and business practices.

Development

Environmental Accounting

For JIao et al., (2022) environmental accounting (EA) is an integral part of any decision making process at the executive level is environmental impact assessment, which is defined as the integration of financial and cost

accounting with the aim of decreasing environmental costs, effects and hazards. It is seen as a possible way to achieve sustainability. Moreover, with this method of accounting, companies can better meet their environmental protection obligations with little impact on their bottom line. Moreover, these procedures are fast becoming the standard by which organisations are judged on their sustainability efforts in relation to their related competitors. This characteristic of CA also makes it stand out and gives it an advantage over its competitors.

Sustainability

Sustainability is primarily defined as an approach to development that aims to achieve a harmonious balance between economic prosperity, environmental preservation and equity in society. This concept implies establishing a harmonious relationship between human activities and the environment in which they take place, encompassing economic, environmental and social aspects (Jiao et al., 2023). In other words, sustainability seeks to promote practices that meet the needs of the present without compromising the potential of future generations to meet their own needs. This implies not only considering the economic aspects of an activity, but also its long-term environmental and social impact (Ogbonna et al., 2020; Dahash & Abdlamer, 2022).

Sustainability is therefore not only about conserving natural resources, but also about ensuring that equitable economic and social opportunities are available to all other people. It is a holistic approach that recognises the interconnectedness between human well-being, environmental health and economic stability, with the ultimate goal of ensuring a prosperous and just future for all (Ogbonna et al., 2020).

MATERIALS AND METHODS

The method employed in the study adopted a mixed approach, combining quantitative and qualitative qualities, in order to carry out an assessment of the material with rigour of description supported by bibliometric tools. This approach is based on the steps of the Systematic Literature Review (SLR), which promote transparency and replicability in the process.

In the first stage, the objectives of the study were established and the selection guidelines were defined, using the Scopus database as the primary source of information. The search terms, "sustainability" and "environmental accounting", and in Spanish, were selected considering their frequent use in the relevant scientific literature.

In the second stage, inclusion and exclusion criteria were defined to identify relevant publications, resulting in an initial set of 366 papers. After applying these criteria, 104 papers were selected for further analysis. The analysis was limited to publications published between 2015 and 2024, resulting in the identification of 54 relevant publications.

Finally, in the third stage, the results of the descriptive analysis of the essential orientations, the thematic clusters identified and the collaboration networks between researchers and countries were presented. These results were presented graphically using specialised software, such as VOSviewer, to facilitate their interpretation.

This methodological approach provides a comprehensive and systematic understanding of the scientific literature that has been produced around these issues, which can contribute to knowledge in the area of business management.

RESULTS

This study makes it possible to establish some clarifications about the spectrum of scientific research that has been carried out on the topics of interest for the study. In this way, after the process of evaluation and analysis of the publications on environmental accounting and sustainability. According to the proposed method, the descriptions present papers that mainly relate CA to sustainability by country of origin, by economic sector and by type of companies. This implies an explanation of the relevance of applying sustainable practices, with the objective of showing the related and effects of CA and sustainability in these.

Thus, the results present a characterisation of the linked publications, highlighting elements with: the approach, scope, units analysed, sample sizes, application scenarios, design, procedures and data collection instrument,

and devices for processing and organising the information. In the delimited period, it was observed that the year with the most publications was 2019, with 10 documents equivalent to 16%, followed by 2015 with 9, which is equal to 14%, then 2018, with 7 documents, corresponding to 11%, then 2016, 2020 and 2022 with 6 articles each, representing 10%, followed by 2016, 2021 and 2024 with 5 documents each, representing 8%, and finally 2023, with 4 equal to 6% of the total (Figure 1).

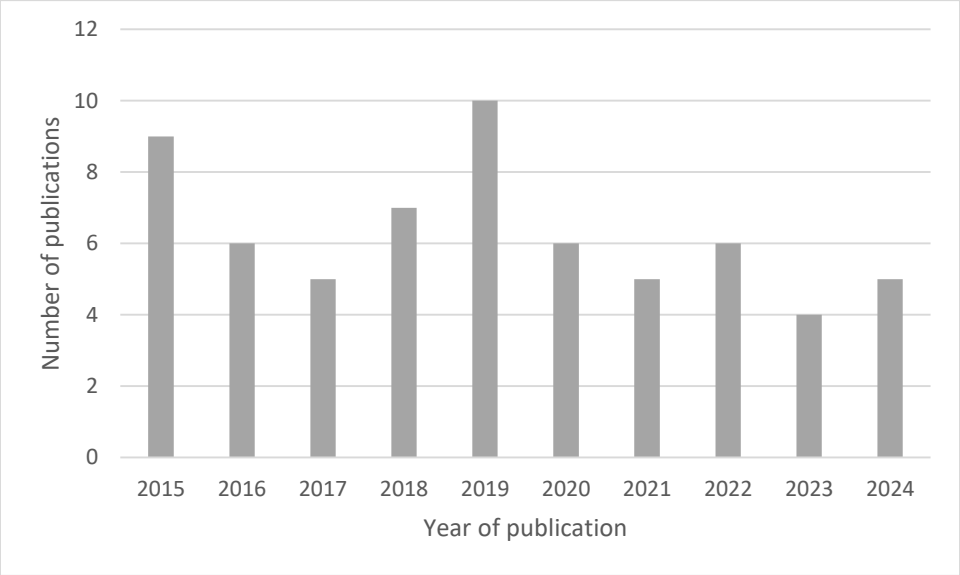

Figure 1 Distribution of publications, 2015-2024.

Source: own elaboration of the different databases.

In relation to the significance of the material by year, the number of citations, broken down by year, was used to identify the ten most cited texts during the period examined, which are detailed in Table 1. In this regard, Vaarst et al. (2015) highlight the urgent need to move from unsustainable production processes and behaviours towards changes in awareness and commitments to sustainability through measures such as raw material substitution, renewable energy use, advances in technologies, sustainability practices and reformed public policies. Ratifying these assertions, Gelbman & Hammerl (2015) expressed that they are particularly noteworthy, ranging from ideas for reusing waste and replacing commodities with greener alternatives, to improving transformation processes by reducing waste generation and gas or substance emissions, with both economic and environmental benefits. Furthermore, Nielsen & Jorgensen (2015) emphasise the importance of management practices focused on sustainability, through various instruments or processes of their own. Furthermore, they analyse the lack of criticism towards accounting resources in typical management.

Table 1 ***Top publications with the most citations, 2015-2024***

Author and year	Document title	Number of citations
Vaarst et al. (2015)	"Sustainable development perspectives of poultry production".	68
Gelbman & Hammerl (2015)	"Integrative re-use systems as innovative business models for devising sustainable product-service-systems".	86
Nielsen & Jorgensen (2015)	"Sustainability analysis of a society based on exergy studies - a case study of the island of Samsø (Denmark)".	57
Stock & Seliger (2016)	"Opportunities of Sustainable Manufacturing in Industry 4.0".	52
Kopnina (2016)	"The victims of unsustainability: a challenge to sustainable development goals".	112
Severo et al. (2017).	"Cleaner production and environmental management as sustainable product	66

	innovation antecedents: A survey in Brazilian industries".	
Carvalho et al. (2018).	"Manufacturing in the fourth industrial revolution: A positive prospect in sustainable manufacturing".	212
Lemus-Aguilar et al. (2019)	"Sustainable Business Models through the Lens of Organizational Design: A Systematic Literature Review".	40
Mensah, J. & Ricart C., S. (2019)	"Sustainable development: Meaning, history, principles, pillars, and implications for human action: Literature review.	629
Bocken et al. (2021)	Unsustainable business models-Recognising and resolving institutionalised social and environmental harm".	75

For Stock & Seliger (2016) an improvement of the long-term viability of industrial value creation is related to Industry 4.0. In the current literature, this phase is mainly described as an improvement of sustainability from an environmental perspective. Interlinked intelligent value creation modules enable a more efficient allocation of resources, including products, materials, energy and water. While Kopnina's (2016) experience suggests that overcoming the current situation requires that we must invoke ethical duty towards the ecosystem and its elements. The dominant discourse on sustainability is fundamentally anthropocentric and fails to identify the true locus of unsustainability; this ethical approach to unsustainability can successfully address these shortcomings. Whether through political or managerial actions.

In turn, Severo et al., (2017) expressed that their results indicate that cleaner production and environmental management positively influence sustainable product innovation. Firms engaged in sustainable product innovation performed better financially than their peers. As there is a strong correlation between cleaner production and environmental management practices. Thus, financial performance as an indicator providing valuable information in management decision making regarding the implementation of sustainability programmes, ultimately leading to greater financial gains through sustainable product innovations.

Carvalho et al. (2018), meanwhile, explain that these industry management streams are a key aspect, and the benefits of the new industrial model have been highlighted in the scientific literature. These benefits include shorter product life cycles, more efficient manufacturing processes made possible by cyber-physical systems that adhere to the principles of the model (e.g. decentralisation, virtualisation, interoperability), and greater responsiveness to changes in natural resource availability and environmental costs. By working in smaller batches, production waste can be reduced and responses to demand curves can be more accurately predicted.

According to Lemus-Aguilar et al. (2019), most research recognises the importance of teamwork in developing long-term viability in business models. The identification of inter-organisational and social design aspects is crucial for the integration of value networks. The second issue is the paucity of research on the topic of organisational incentives, specifically on topics such as incentive systems and the construction of human behaviour. The third thing that all these examples have in common is that they all show how a change in strategy led to a more sustainable business model. Therefore, an organisational architecture aligned with the business model is what makes strategy implementation possible. Given the value of business models in elucidating strategic business logic, this may suggest that the organisation itself can serve as a useful lens for elucidating tactical business logic, thereby facilitating the implementation of the intended strategy.

Another sense, was put forward by Mensah & Ricart (2019) who from a theoretical stance identify and argue that the three interrelated dimensions of the environment, elements of economy and society are the foundation on which the whole issue of sustainable development rests: equality between and among generations. To preserve and advance the principles of this paradigm for the benefit of human development, decision-makers must maintain a keen awareness of the interdependencies, synergies and trade-offs between these pillars and ensure ethical conduct at global, national, community and personal levels. To ensure that everyone is aware, educated and respectful of sustainable development, key actors - especially the UN, states, the private sector and NGOs - must do more through education, regulation and policy to manage social, economic and environmental resources.

Finally, Bocken et al. (2021) explain that the basis of any strategy formulation is an understanding that sustainable consumption and production, with an emphasis on the processes of transformation of the built environment, is at the heart of any academic debate. Given that the majority of people on the world stage now reside in urbanised spaces, which serve as hubs for both sustainable lifestyle innovations and the spread of less sustainable practices. The themes of these debates should therefore revolve around: Grassroots innovations, shared urban food, energy and waste systems, responsibility of industries for implementing sustainable lifestyle changes, consumer values, behavioural change and activism as agents of change, and governance and indicators for monitoring these changes.

According to the data presented in Table 2, most of the articles on sustainability and CA fall within the non-experimental model, with 67%, while experimental studies represent only 1% and quasi-experimental studies 30%. In terms of scope, exploratory studies predominate with 65%, followed by descriptive studies with 20%. Correlational, historical and explanatory studies account for 7%. This indicates that, although there is an abundance of literature on the subject, most of it is based on assessments of existing documentation.

In terms of approaches, the majority lean towards qualitative approaches with 70%, followed by quantitative approaches with 32% and mixed approaches with 8%. It is important to note the significant contribution of mixed papers, as they combine qualitative and quantitative aspects. This has been notable over the last two decades, and is of great use to researchers who expect richness and depth in the content that is published, and when evaluating research design options it gives them scope for replication. In terms of the sectors of the economy that served as benchmarks, the majority are in tertiary sectors, with 48%, followed by secondary sectors, with 34%, and with a minimal proportion for the primary sector, with 2%.

A more detailed analysis of the scope, focus and sectors, around which inquiries were made, reveals that in summary the descriptive ones are predominant, representing 95% of the total. In the tertiary and secondary sectors, the majority of the samples are concentrated in business units, 62%. Likewise, the exploratory ones cover 70% of what was reviewed.

Table 2 ***Methodological approaches to studies, 2015-2024***

Features	Categories	Total, of publications	Percentage distribution
Design	Non-experimental	50	67%
	Experimental	2	1%
	Quasi-experimental	19	30%
Outreach	Descriptive	14	20%
	Correlational	2	3%
	Exploratory	43	65%
	Historical	3	4%
Approach	Quantitative	21	32%
	Qualitative	46	70%
	Mixed	5	8%
Sectors	Primary	1	2%
	Secondary	23	34%
	Tertiary	32	48%
	Not specified	10	16%

Source: own elaboration based on the database.

The information presented in Table 3 reveals that "enterprises" are the most frequently studied units, showing a diversity in distribution that includes "large enterprises", "SMEs", "large and SMEs", "all enterprises", and a syntagm of "not defined". A total of 31 papers focused on "large enterprises", which represents 57% of the total number of units studied. A further 7 papers addressed their research towards "all companies", equivalent to 13%. There were also 5 papers that focused on "large and SMEs", representing 9% of the units studied. On the other hand, 6 papers specifically targeted "SMEs", corresponding to 11%. Finally, there were 5 documents, "not defined", where the size of the enterprises was not specified, representing 9% of the total.

Table 3 ***Company size mentioned in publications, 2015-2024***

Type of companies	No. of items	Percentage distribution
Great	31	57%
SMEs	6	11%
Large and SMEs	5	9%
All	7	13%
Not defined	5	9%
Total,	54	100%

Source: own elaboration based on the database.

In another context, Table 4 presents the distribution of 28 documents according to the unit of study used, with "companies" being the most frequent unit, representing 52% of the total. On the other hand, there are the documents that used "organisations", with 9 documents representing 17% of the total. In addition, there are 8 documents that focused on "articles", representing 15%. Meanwhile, both "countries" and "universities" are listed with 3 papers each, equivalent to 6% of the total. Finally, there are the documents that focused on "review of methods", with 2 documents, representing 4%, and "reports", with 1 document, corresponding to 2% of the evaluated texts.

Table 4 ***Unit of analysis, 2015-2024***

Unit of analysis	Number of publications	Percentage distribution
Articles	8	15%
Companies	28	52%
Organisations	9	17%
Universities	3	6%
Review of methods	2	4%
Countries	3	6%
Reports	1	2%
Total	54	100%

Source: own elaboration based on the database.

Through the documentary analysis of relevant publications and the review of their network maps, the main thematic clusters of research related to CA and sustainability from 2015 to 2024 were identified. Thematic cluster: "Conceptual aspects, 21 documents representing 39%, "Description of processes", 19 texts, corresponding to 35%; "Impact or consequences" with 6 documents, equivalent to 11%; and "Measurement or evaluation devices" with 4 documents and respective to 7%. These data are presented in Table 5, which shows the distribution of documents according to the different thematic clusters.

Table 5 ***Cluster by theme, 2015-2024***

Topics	Number of publications	Percentage distribution
Conceptual aspects	21	39%
Measuring devices	4	7%
Impact or consequences	6	11%
Description of processes	19	35%
Management trends	4	7%
Total	54	100%

Source: own elaboration based on the database.

For data collection, a range of options are available, all of which are effective in obtaining the necessary information. The following stand out: "Documentary analysis", with 15 documents, representing 28% of the total; the use of "existing databases", with 10 documents, equivalent to 19%; "interviews", with 6 documents, representing 11%; and finally, those employing more than one method of data collection, such as "documentary analysis and existing databases", with 5 documents, representing 9% (as shown in Figure 2).

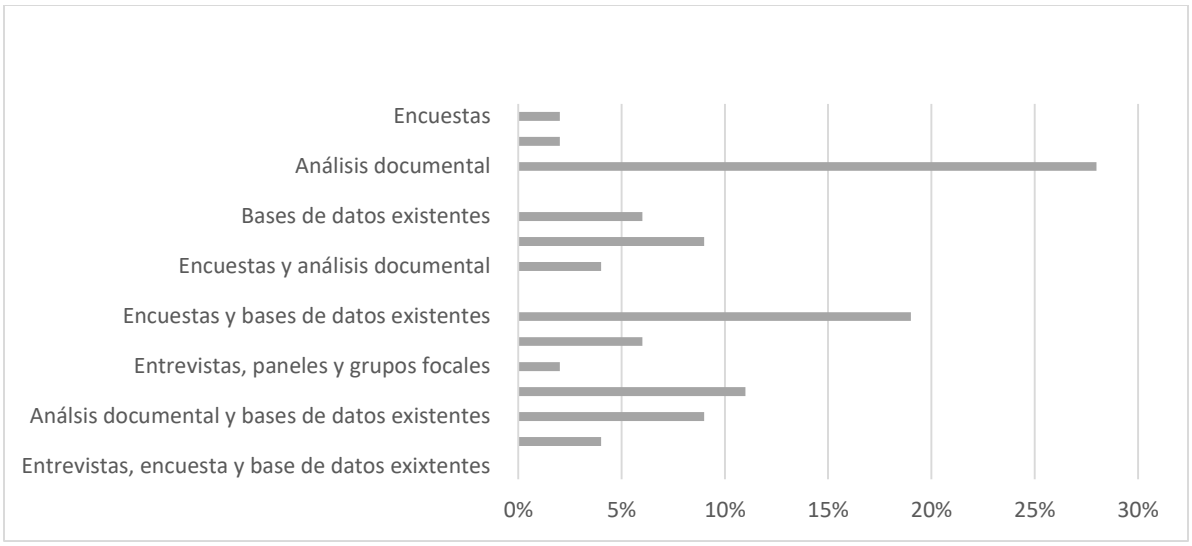

Figure 2 *Data collection techniques for the articles reviewed, 2015-2024*

Source: own elaboration based on the database.

Various methods were used in the analysis of the information, the most predominant being "cluster analysis", which covers 34 documents, representing 44% of the total. This is followed in importance by "measures of association" with 20, equivalent to 37%. Other methods used include "structural equations and cluster analysis", which comprises 5 papers, representing 9%, while "regression" and "canonical correlation" have 1 each, both representing 2%. Then, there are those studies that used more than one form of analysis, i.e. "structural equations and association measures" and "structural equations and cluster analysis", each with 2, representing 4% of the total, as shown in Figure 3.

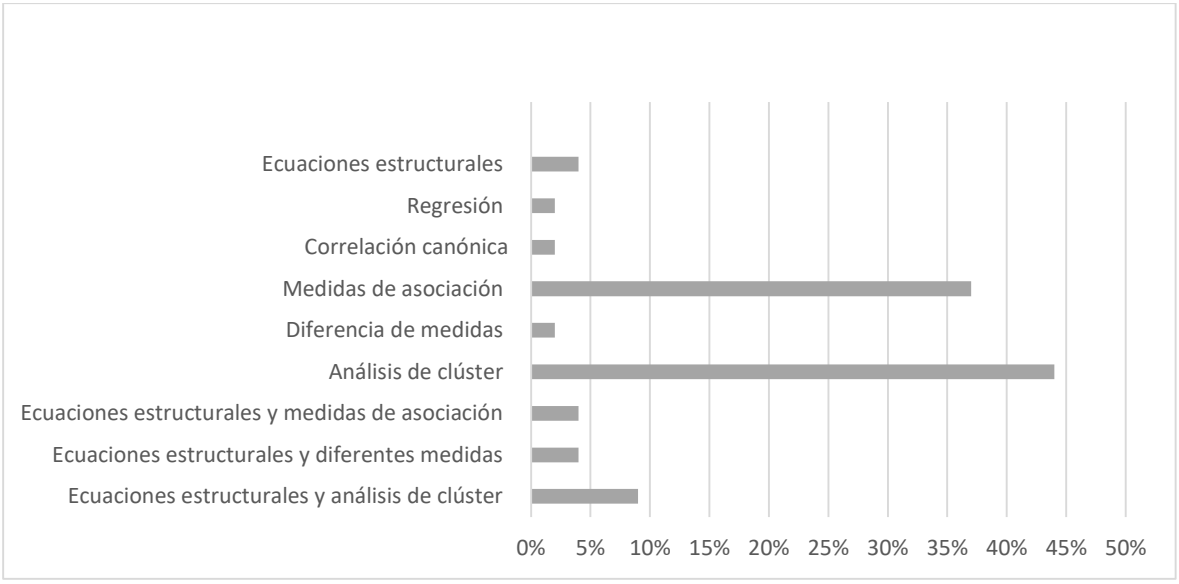

Figure 3 Techniques for analysing data analysis of the articles reviewed, 2014-2024.

Source: own elaboration based on the database.

From the analysis carried out, shown in Figure 4, 18 countries have been identified as having material on the subject. The United States stands out in particular, ranked first due to its largest number of publications, with 12 papers representing 18%. It is followed by Australia and the United Kingdom with 10 each, equivalent to 15% of the total, while Italy has 7 papers, representing 10%. These findings underline the importance of certain

countries in the research and dissemination of works on the subject. Furthermore, in Latin America, Brazil stands out as one of the main producers in this field, representing 1% of the total in this study.

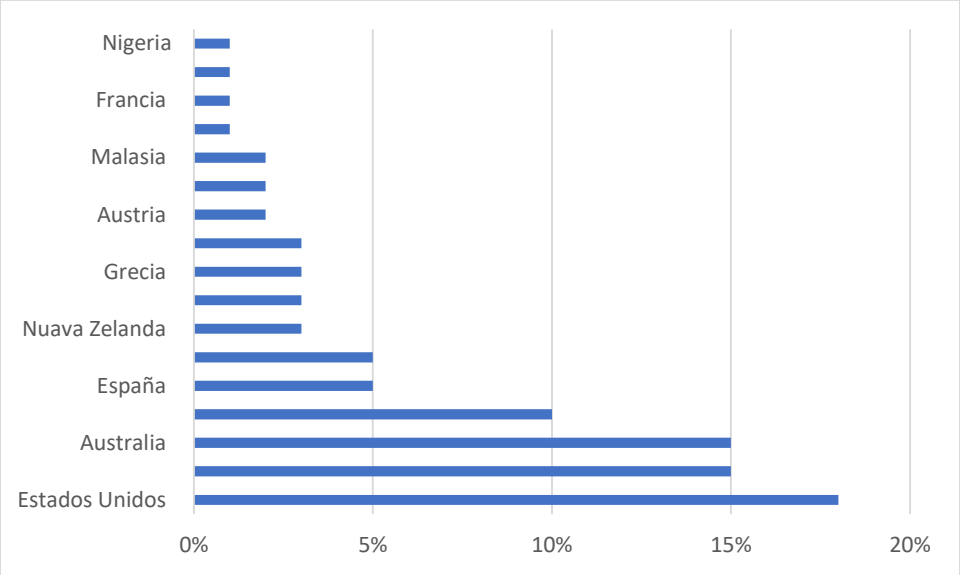

Figure 4 Countries with scientific production, according to the number of citations registered in databases, 2015-2024

Source: own elaboration based on the database.

Figure 5 shows the journals with the highest number of publications in the scientific field. Based on the data provided, 27 journals were identified as having published a total of 54 papers during the period from 2015 to 2024. Among these, 17 journals are ranked as the journals that have published the least number of papers in that period. Notable among them is "Meditari Accountancy Research", which accounts for 2% of the total number of reviewed publications. The "Journal of Cleaner Production" is the journal with the most publications, a total of 16, which represents 24%.

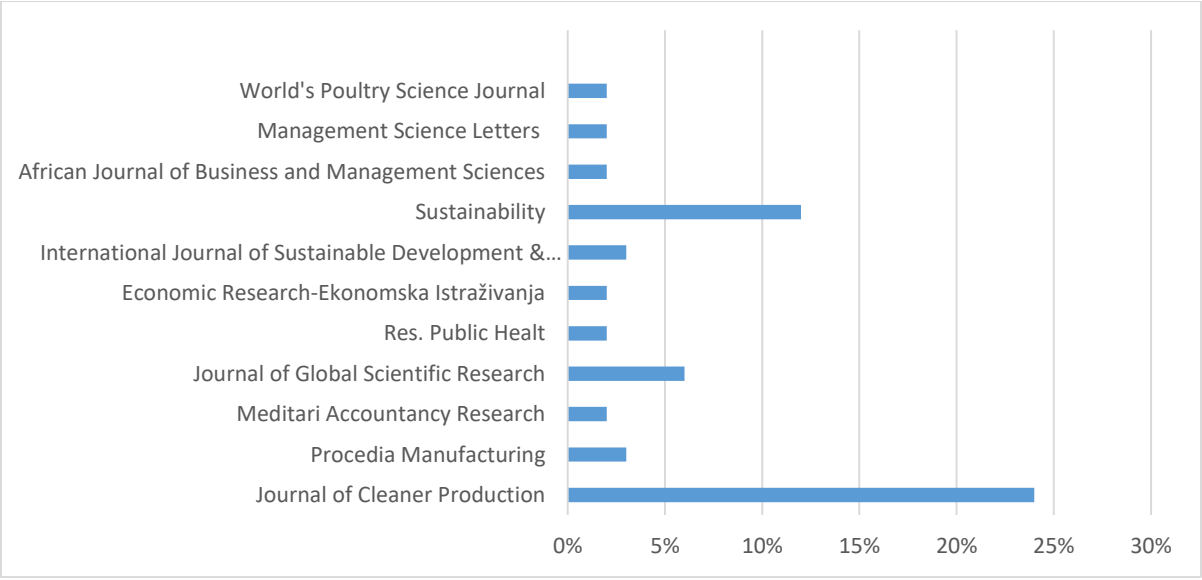

Figure 5 Percentage distribution of top journals, 2015-2024.

Source: own elaboration based on the database.

With regard to the organisation and representation of journal data, the VOSviewer software made it possible to identify the networks of cooperation in research on the subject, which are presented in collaboration maps

of authors from various countries of different nations. Figure 6 displays them, highlighting the most prominent clusters, considering the following criteria: a) At least one collaborative work; and b) At least 50 citations. Among the results, the 13 most representative clusters are distinguished. Namely: Vaarst et al. (2015); Gelbman & Hammerl (2015); Nielsen & Jorgensen (2015); Stock & Seliger (2016); Kopnina (2016); Severo et al. (2017); Carvalho et al. (2018); Lemus-Aguilar et al. (2019); Mensah, J. & Ricart C., S. (2019); Bocken et al. (2021).

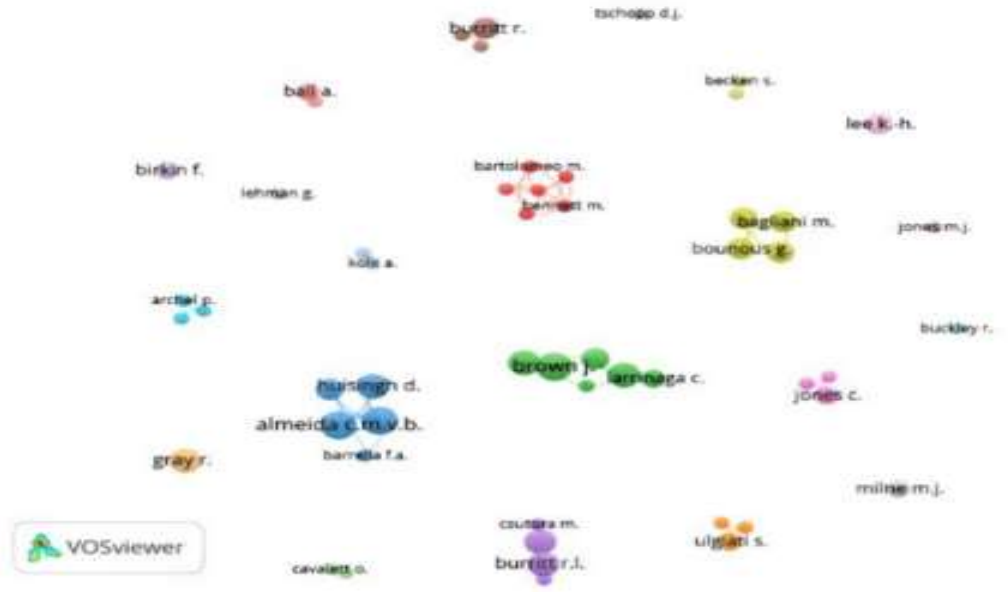

Figure 6 *Author networks, 2015-2024*

Source: own elaboration based on the database.

Figure 7 illustrates the collaboration networks between countries, showing the clusters among them that have contributed at least 1 in this field of study. The results reveal the existence of 16 collaboration clusters in this field: Canada, Germany, Hungary and the Netherlands; Australia, Spain and the United Kingdom; China, Denmark and Sweden; Australia, Japan and Brazil; Italy, Norway and Poland; Malaysia, New Zealand and South Africa; Brazil, France and the United States; Greece, Finland, Hong Kong, Nigeria, Ireland, Lithuania, Romania and Thailand. In Latin America, only Brazil has recorded relevant scientific publications in collaboration with France and the United States in the field of sustainability and CA.

CONCLUSIONS

The findings presented in this study represent a valid contribution in the field of Environmental Accounting (EA) and sustainability, thanks to the thoroughness of methodology and the global perspective adopted in this specific subject. The identification of trends in scientific research provides a rigorous overview, as reflected in the analysis of 54 relevant scientific publications on CA and sustainability in the global scenario between 2015 and 2024.

The results highlight the relevance of adopting sustainable practices, revealing the paths followed by others, and the general significance in other countries, economic sectors and companies. There is a predominance of qualitative research in this field, accounting for 70% of the publications, while quantitative approaches constitute only 32%. The focus is on the tertiary sector of the economy (48%), followed by the secondary sector (34%).

As it allows for an exploratory scope of data analysis, documentary analysis is the most widely used technique for data collection. With regard to the thematic groups, the majority of publications (39% and 35% of all relevant publications, respectively) deal with conceptual elements and process characteristics.

During the study period, an increase in publications was observed in 2015 and 2019, with the United States being the country with the most publications, although the Journal of Cleaner Production from the Netherlands is the scientific journal with the most citations. In addition, it is emphasised that the cluster of authors leads in scientific collaborations, while Australia, Spain and the United Kingdom stand out as the countries with the highest production in the field of study.

The aim of this effort is to help managers, educators, researchers, practitioners and students learn more about CA and how to incorporate sustainable practices into the management of their companies. It contributes to the creation of a theoretical framework, effective implementation in organisations and a better understanding of these challenges. Companies are adopting sustainable techniques to reduce their impact on the environment, indicating that this field is becoming increasingly important globally. Further research is needed on the effective incorporation of sustainability criteria into organisational management and applied studies in organisations to evaluate CA as a tool to enhance the adoption of sustainable practices.

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