# New technologies in supporting ESG criteria and the implementation in the new normal: mapping the field and proving future research paths

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## Abstract

This paper provides a structured literature review (SLR) on new emerging technologies supporting the Environmental, Social and Governance aspects (ESG) to identify the interdependencies and relationships between these two areas. Using a rigorous methodological approach, the study summarises the state of the art of the past literature on the topic, which has grown significantly in importance in recent years. The analysis has been conducted on 204 papers extracted from the Scopus database using the Blibliometrix R package. Additionally, using the SLR road, we provide a bibliometric and coding analysis focused on papers published in different academic journals in the business management and accounting field. Our results discover three strands of research: new emissions control technologies, new sustainability assessment management technologies, and disruptive energy management technologies. These results demonstrate the originality of the paper that resides in a novel analysis concerning the recent role played by innovation technologies in sustainability. The study reveals the need for more holistic research and an integrated framework that consider the technological aspects related to ESG criteria, and not consider the two separately as in the present literature. Related to that, there is also the demand for a deeper exploration about the role that new technologies play in the various sustainability initiatives. Finally, the article addresses future research perspectives and paths as joint scholars and practitioners' analysis.

*Keywords:* Sustainability, ESG, new technologies, climate change, technological innovation, sustainable development

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## Sommario

Il presente lavoro fornisce una revisione strutturata della letteratura (SLR) sulle nuove tecnologie emergenti a supporto degli aspetti ambientali, sociali e di governance (ESG) per identificare le interdipendenze e le relazioni tra queste due aree. Utilizzando un approccio metodologico rigoroso, lo studio riassume lo stato dell'arte della letteratura passata sull'argomento, la cui importanza è cresciuta in modo significativo negli ultimi anni. L'analisi è stata condotta su 204 articoli estratti dal database Scopus utilizzando il pacchetto R Blibliometrix. Inoltre, utilizzando la strada SLR, forniamo un'analisi bibliometrica e di codifica incentrata su articoli pubblicati in diverse riviste accademiche nel campo della gestione aziendale e della contabilità. I nostri risultati hanno evidenziato tre filoni di ricerca: nuove tecnologie di controllo delle emissioni, nuove tecnologie di gestione della valutazione della sostenibilità e tecnologie di gestione energetica dirompenti. Questi risultati dimostrano l'originalità del lavoro, che risiede in un'analisi inedita del recente ruolo svolto dalle tecnologie innovative nella sostenibilità. Lo studio rivela la necessità di una ricerca più olistica e di un quadro di riferimento integrato che consideri gli aspetti tecnologici legati ai criteri ESG e non li consideri separatamente come avviene nella letteratura attuale. In relazione a ciò, vi è anche la richiesta di un'esplorazione più approfondita del ruolo che le nuove tecnologie svolgono nelle varie iniziative di sostenibilità. Infine, l'articolo affronta le prospettive e i percorsi di ricerca futuri come analisi congiunta di studiosi e professionisti.

*Keywords:* Sostenibilità, ESG, nuove tecnologie, cambiamento climatico, innovazione tecnologica, sviluppo sostenibile

## 1. Introduction

Environmental, social, and governance (ESG) considerations have become increasingly important for businesses and investors in recent years. Integrating ESG factors into business practices and investment decisions promotes sustainable development and mitigates risk. New technologies have the potential to play a significant role in advancing ESG goals being a new normal for businesses. For example, artificial intelligence (AI) is increasingly used to support ESG development (Sætra, 2021). AI is becoming a key enabler of the digital transformation (Holmström, 2022). One fundamental application of AI in ESG is analysing ESG data (Macpherson *et al.*, 2021). With a large amount of data available on environmental and social metrics, AI can identify patterns, trends, and risks that may not be immediately apparent to human analysts (Breeman, 2021). AI algorithms can also be trained to scan new articles and social media posts for ESG-related content. This allows real-time monitoring of stakeholder sentiment and emerging issues or helps develop ESG assessment (Sætra, 2023). Furthermore, AI can also be used to support ESG goals by developing new products and services. For example, AI-powered energy management systems can help companies to reduce their carbon footprint and lower energy costs (Crawford, 2021). Similarly, AI can optimize supply chain

operations and reduce waste, contributing to environmental and social goals (Dash *et al.*, 2019). Another interesting technology is the blockchain. For instance, it is widely adopted to improve supply chain transparency, while artificial intelligence can help identify ESG risks and opportunities. Additionally, the emergence of renewable energy technologies and the increasing availability of environmental and social metrics data provide new ways to measure and monitor ESG performance using blockchain (Calandra *et al.*, 2023). As such, understanding the role of new technologies in ESG development is becoming increasingly important for businesses, investors, and policymakers (Secinaro *et al.*, 2021). Therefore, new technologies may boost ESG adoption and accountability, giving more powerful tools to create, manage and implement a new normal road for businesses (Stein Smith, 2020).

In general, we are experiencing a growing awareness of the importance of integrating environmental, social and governance considerations into business practices and investments decisions. As ESG factors have gained prominence, there is a need to understand the role of new technologies in achieving ESG goals and driving sustainable development.

Despite the widespread interest in new emerging technologies, it is difficult to observe a holistic bibliometric framework regarding the broader concept of these new technologies in ESG management. Therefore, the study offers a structured literature review (SLR) starting from a constructivist framework based on sound theoretical findings that frame ESG management as a development factor and aims to provide evidence about the most relevant variables in the literature, such as authors, citations, journals, and countries of publication (Lim *et al.*, 2022; Macchiavello & Siri, 2022). Our analysis will benefit from the paper of Massaro *et al.* (2016) and Paul & Criado (2020), which aim to create a transparent and reliable analysis to be updated by other researchers. Additionally, using cluster analysis, we will foster the exploration of the scientific debate in this field. We adopt the "Bibliometrix" R package (Aria & Cuccurullo, 2017). Adopting a structured keyword search methodology thoroughly analysed in the methodology section, this article explores 240 sources.

The study identifies two main research questions that aim to answer (Massaro *et al.*, 2016) and that can be expressed as follows:

*RQ1.* What are the main bibliometric variables (citations, sources and keywords) related to new technologies supporting ESG management?

*RQ2.* In what areas are such technologies most likely to be applied?

The first research question aims to define the "state of the art" in the literature about the emerging technologies that allow the identification and

monitoring of ESG aspects. The second research question can guide the researchers to use such technologies to comply with ESG criteria.

The research analysis aims to define state-of-the-art in the literature by examining emerging technologies that identify and monitor ESG aspects. This provides a comprehensive overview of some of the most important technological tools available for ESG management, which can be valuable for researchers and practitioners. Furthermore, the research seeks to identify the areas where these new technologies will most likely be applied in ESG management. By uncovering potential applications, the research offers insights into how these technologies can be used to comply with ESG criteria and address climate change issues and sustainability agendas.

Our article has interesting implications. Regarding theoretical elements, we provide an initial discussion on technological tools for ESG management using bibliometric variables useful for researchers in starting new projects and writing future studies. Additionally, our analysis identifies some relevant implication that links sustainability assessment and the accountability field.

Regarding practical implications, our study aims to foster technological applications using different kinds of technologies, depending on the field of application, for ESG management in addressing new climate change issues and agendas. For example, we found that the agriculture sector makes extensive use of AI (Das *et al.*, 2018) as well as blockchain technology can be used to improve sustainability assessment management practices, providing different data and information depending on specific needs (Shojaei *et al.*, 2019). At the same time, many of the engineering technologies available today contribute to increased electricity efficiency (Baggini, Sumper, 2012).

The study will proceed as follow. Section 2 gives an overview of the methodological workflow followed by the research team. Section 3 provides an in-depth data interpretation, comments, and critique of the main findings. Finally, section 4 discusses and concludes the article with a summary of the current state-of-the-art and recommendations for possible future research directions.

## 2. Methodology

The paper adopts a hybrid methodology to facilitate a rigorous qualitative and quantitative examination of studied sources, combining bibliometric and code analysis (Cobo *et al.*, 2011; Massaro, Dumay, *et al.*, 2016). This method is based on the structured literature review (SRL) that requires sequenced and replicable processes (Tranfield *et al.*, 2003). According to Secinaro *et al.* (2021) and Zupic & Čater (2015), the bibliometric approach considers a series of

variables such as years, documents' information, sources, authors, keywords, citations, and countries. Additionally, coding analysis allows further investigation and gathering of data on other elements such as definitions, research methodologies, accounting and accountability implications, emerging technologies and connections with ESG criteria (Moher *et al.*, 2009; Secinaro, Dal, *et al.*, 2021). Combining such two analysis sources may allow a holistic overview of specific research flows.

According to the literature (Christoffersen, 2013; Dumay & Cai, 2014; Massaro *et al.*, 2015; Thorpe *et al.*, 2005), there are various approaches for identifying the article to review and, in this case, the method adopted is based on five crucial steps:

1) Definition of the research questions that the literature review aims to answer;
2) Write research protocol;
3) Determine the type of papers to analyze;
4) Develop a coding framework;
5) Perform critical analysis and discussion, identifying future research and path.

The first step is defining the two research questions the study aims to answer (Massaro *et al.*, 2016). Then it would be essential to write a research protocol containing the definition of information sources, the methods adopted, the mean and tools used for testing and synthesizes the studies (Petticrew & Roberts, 2006). Table 1 illustrates the review protocol and the different steps into which it is divided, including the main topic, the motivation of the choice, dataset creation and the tools used to implement the analysis.

The third step would be to determine the different kinds of sources and studies included and carried out in the literature review, using the scientific database Scopus (Mishra *et al.*, 2017).

Afterward the fourth phase has the objective of defining the items to be examined in the selected papers through the setting up of a coding framework. The study identified the following items for coding:

1) *Timing of publication*: the evolution over the time of the number (Nr) of papers;
2) *Geographic distribution of papers*: papers distribution among countries;
3) *Journals*: distribution of papers among journals and citations received;
4) *Author and citations analysis*: number of citations of articles, citations per year, citations per year (CPY) ranking;
5) *Relevant keywords and topics*: the most frequent of authors' keywords used.

*Table 1. Research review protocol*

| Research protocol elements | Author's consideration |
|---|---|
| What is already known? | There is a strong demand to investigate what are the new and emerging technologies that assist in fulfilling and monitoring ESG criteria (Li *et al.*, 2021). Nowadays, people's attention is increasingly shifting towards the need to act in a responsible and sustainable direction in order to ensure that organisations have their place in the economy in the long term (Zumente & Bistrova, 2021). The emphasis is also growing on the preservation of long-term stakeholder value and sustainability (Bistrova & Lace, 2012). |
| Motivation | ESG aspects are becoming fundamentally important within the international framework in order to reduce atmospheric pollutant emissions and align with globally established targets. There is a potential for a bibliometric and open coding analyses examining which are the emerging technologies that can be used in the implementation of ESG-compliance models for different sectors. |
| Research topic | The study deals with two different areas of research. On the one hand, the analysis of new technologies available on the market, highly investigated in many papers and articles as they are applicable to a plurality of contexts. On the other hand, ESG criteria and the need to find new methods to measure and manage them.<br>**RQ1:** What are the main bibliometric variables (citations, sources and keywords) related to new technologies supporting ESG management?<br>**RQ2:** In what areas are such technologies most likely to be applied? |
| Journal's research | It was decided not to limit the research to individual scientific journals because of the still young purpose (Secinaro, Dal, *et al.*, 2021). The analysis included articles and peer-reviewed journals (Easterby-Smith *et al.*, 2012). In addition, the study selected business, management and accounting sources from Scopus database to extract all relevant information sources (de Villiers & Dumay, 2014). |

*Source: Authors' elaboration*

6) *Geographic distribution of papers*: papers distribution among countries;
7) *Journals*: distribution of papers among journals and citations received;
8) *Author and citations analysis*: number of citations of articles, citations per year, citations per year (CPY) ranking;
9) *Relevant keywords and topics*: the most frequent of authors' keywords used.

Finally, the last phase of SRL aims to perform a critical analysis and discussion of the selected sources, identifying future research and path. This critical final step is combined with a bibliometric analysis in order to minimize errors and to increase the value of the research outcomes (Fahimnia *et al.*, 2015; Feng *et al.*, 2017). The research team conducted a keywords analysis to investigate appropriate scientific information about emerging technologies connected to ESG criteria (Bamel *et al.*, 2021; Bedford, 2015; Fteimi & Lehner, 2018). Hence, we used the following keywords research string within the Scopus database:

*( TITLE-ABS-KEY ( esg ) OR TITLE-ABS-KEY ( sustainability ) OR TITLE-ABS-KEY ( "climate change" ) AND TITLE-ABS-KEY ( accounting ) OR TITLE-ABS-KEY ( auditing ) OR TITLE-ABS-KEY ( accountability ) AND TITLE-ABS-KEY ( "technolog*" ) OR TITLE-ABS-KEY ( blockchain ) OR TITLE-ABS-KEY ( "artificial intelligence" ) OR TITLE-ABS-KEY ( "machine learning" ) OR TITLE-ABS-KEY ( "deep learning" ) OR TITLE-ABS-KEY ( supercomputing ) OR TITLE-ABS-KEY ( "edge computing" ) OR TITLE-ABS-KEY ( "data storage" ) OR TITLE-ABS-KEY ( "distributed ledger technologies" ) OR TITLE-ABS-KEY ( "cloud computing" ) ) AND ( LIMIT-TO ( SUBJAREA , "BUSI" ) ) AND ( LIMIT-TO ( DOCTYPE , "ar" ) OR LIMIT-TO ( DOCTYPE , "re" ) ) AND ( LIMIT-TO ( LANGUAGE , "English" ) ) AND ( EXCLUDE ( PUBYEAR , 2023 )).*

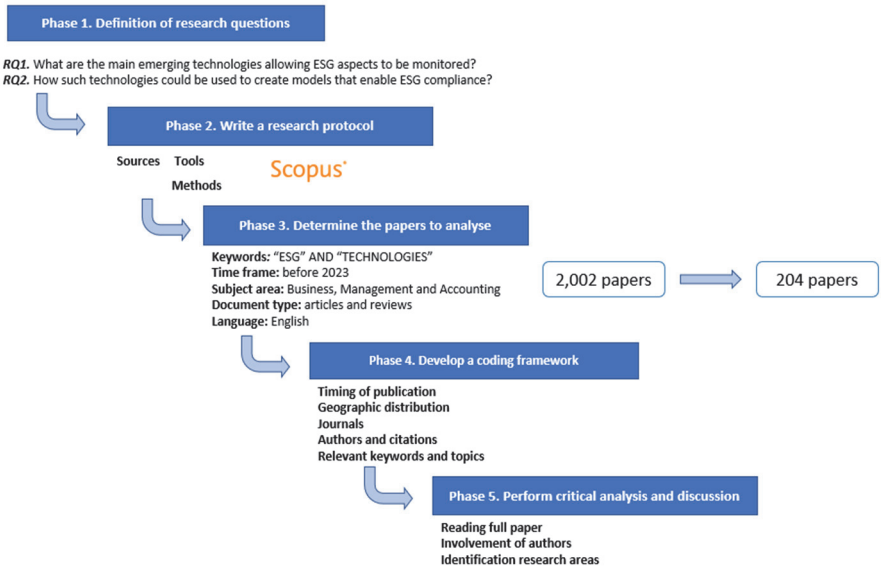
Furthermore, to refine the search process, we included some limitations, such as considering only peer-reviewed articles and reviews written in English. All documents were selected within the business, management, and accounting areas because the RQs are strictly related to these fields. These criteria result in being reproducible, comprehensive, and unbiased.

First, we obtain a working list of 2,002 documents from the previous search string. Considering only the business, management, and accounting fields, we gather 305 results. Then, after applying the document type limitation, only 215 peer-reviewed articles and reviews remain. Finally, we considered only papers published in English, about 204 results before 2023.

Figure 1 represents the complete process of paper selection:

1) A total of 2,002 papers emerged from the Scopus database, using the previous search string;
2) A total of 305 papers and articles resulted considering only the business, management, and accounting fields;
3) There were 204 results after selecting only peer-reviewed articles and reviews before 2023, written in English.
4) A CVS format file was extracted with the following items: title, abstract, author(s), authors' keyword, number of citations, years, affiliation, sources and references.

Figure 1. *Research design and phases*




*Source: Author's elaboration*

## 3. Research findings

This section presents the main evidence from the systematic literature review, answering the previous research questions. The remaining section is structured in two parts: a bibliometric analysis of the selected papers and a content analysis concerning a deeper insight into the selected papers.

### *3.1. Main information, citations, and countries' collaboration*

Table 2 illustrates the main information about the data under analysis. The articles are published in 100 different sources, such as journals, books, etc. The average publication rate was 5.95 articles per year during the relevant publication period. Furthermore, each document was cited approximately 33 times. The average of 804 keywords shows the relevance of this topic, which is not considered in many different research fields (Bhatt *et al.*, 2020; Secinaro & Calandra, 2020). Additionally, the average of co-authors' articles (3,25) confirms that the purpose of the research is particularly collaborative. Only 34 articles have a single author signature and so, for example, written by only one author.

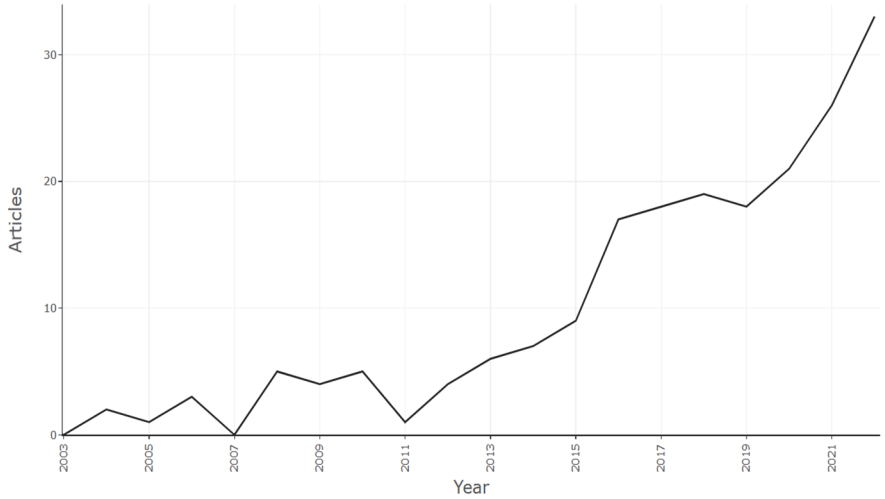
Table 2. *Main information about the data*

| Description | Results |
|---|---|
| **MAIN INFORMATION ABOUT DATA** | |
| Timespan | 1997:2022 |
| Sources (Journals, Books, etc) | 100 |
| Documents | 204 |
| Annual Growth Rate % | 11,87 |
| Document Average Age | 5,95 |
| Average citations per doc | 32,61 |
| References | 1 |
| **DOCUMENT CONTENTS** | |
| Keywords Plus (ID) | 1221 |
| Author's Keywords (DE) | 804 |
| AUTHORS | |
| Authors | 626 |
| Authors of single-authored docs | 33 |
| **AUTHORS COLLABORATION** | |
| Single-authored docs | 34 |
| Co-Authors per Doc | 3,25 |
| International co-authorships % | 31,37 |
| **DOCUMENT TYPES** | |
| article | 188 |
| review | 16 |

*Source: Author's elaboration*

Simultaneously, as shown in Figure 2, researchers' interest in the subject has grown. Throughout the period from 2003 to 2011, 30 articles were published. In the following period, starting from 2011 to 2019, it is possible to observe a consolidation in publications. Finally, the line graph demonstrates a significant increase in publications, which have risen from 18 to 33 between 2019 and 2022. This trend reveals the actuality of the research topic. This is also explained by the increased publication of practical reports and supranational decisions addressing and boosting corporate social responsibility practices. (European Union, 2023).

Figure 2. *Annual scientific production*




*Source: Author's elaboration suing Bibliometrix*

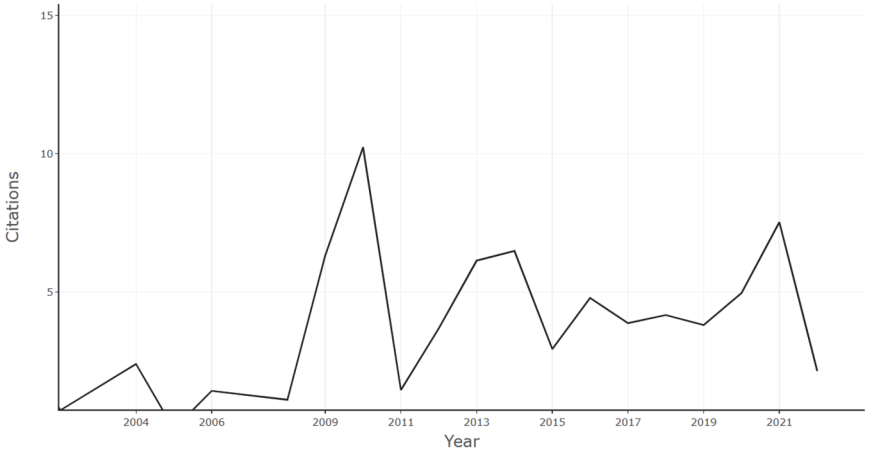
Considering the average quotations received by the 204 documents analysed between the period from 2002 to 2022, some interesting results emerge (Figure 3). Firstly, there is a considerable fluctuation in the number of citations per year, especially from 2002 to 2015. The trend is extremely variable; during this period, the course of citations reached 10.2 in 2010. The researcher's citation fluctuation partly reflects the observed publication modifications until 2013. From 2015 onwards, the number of citations partially stabilised by maintaining a constant trend with no more drastic ups and downs. However, the trend reached its second high of 7.5 in 2021, plunging the following year dramatically.

The following Table 3 shows that the ten most frequently cited articles were written throughout the period from 1997 to 2016. Thus, the most cited paper has 777 citations, with an average of about 29 total citations per year, representing a milestone within this field of research. The most cited work is that of Edvinsson (1997), which focuses on Intellectual Capital as neither 'human capital' nor 'structural capital' are represented in traditional accounting systems even though it is a renewable, as well as renewing resource that must be cultivated in a context. Schneider *et al.* (2010) discuss sustainable degrowth, defined as equitable downscaling of production and consumption that increases human well-being and enhances ecological conditions at the local and global level in the short and long term. In the literature is also widely

agreed that new tools are required to foster democracy and to focus on the sustainability arena for illustrative purposes (Brown, 2009). One of these tools is integrated reporting which enables an open dialogue between individuals and groups capable of assisting or obstructing efforts to foster sustainable business practices (Brown & Dillard, 2014). In the same line of research is also the contribution of Calabrese *et al.* (2016). Sun *et al.* (2021) investigate the impact of environmental subsidies on environmental innovation, showing that they do not significantly impact environmental technology innovation. Considering bioplastic production, Campo Iles & Martin (2013) illustrate how business models can link producers and customers by developing new technologies and products. Additionally, Bonilla *et al.* (2010) analyze the role of cleaner production in the sustainable development of modern societies. Considering water footprinting and mining, Northey *et al.* (2016) demonstrate that opportunities exist for technology assessment and improving industry reporting. At the same time, the research findings of Moran *et al.* (2014) correspond to similar lines of research.

The results obtained referring to the map of geographical collaboration among the authors of the paper under consideration (Figure 4) and the corresponding explanatory table (Table 4) are particularly interesting. As shown, the authors' most significant collaboration occurs between China and USA, followed by Australia and New Zealand. Collaborations between China and Italy rank third and are immediately succeeded by China with Japan.

Figure 3. *Annual scientific production*




*Source: Author's elaboration suing Bibliometrix*

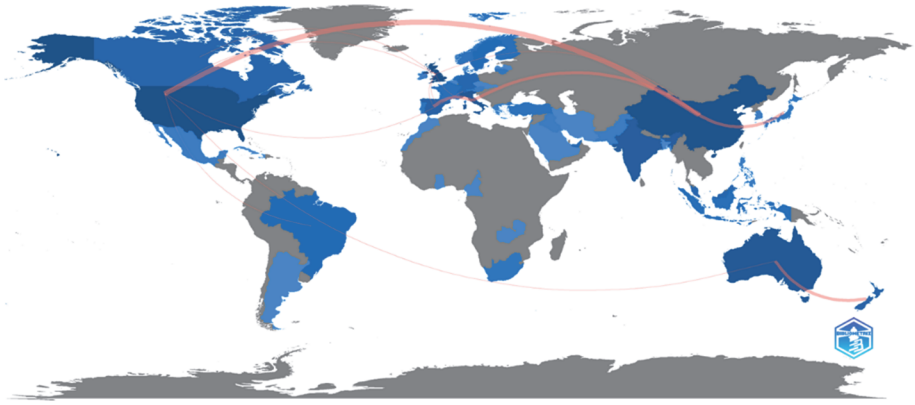
Table 3. *Most global cited documents*

| Paper | Total citations | Total citations per year |
|---|---|---|
| (Edvinsson, 1997) | 777 | 28,78 |
| (Schneider *et al.*, 2010) | 565 | 40,36 |
| (Brown, 2009) | 281 | 18,73 |
| (Brown & Dillard, 2014) | 233 | 23,30 |
| (Sun *et al.*, 2021) | 197 | 65,67 |
| (Iles & Martin, 2013) | 164 | 14,91 |
| (Calabrese *et al.*, 2016) | 115 | 14,38 |
| (Bonilla *et al.*, 2010) | 113 | 8,07 |
| Northey *et al.* (2016) | 109 | 13,63 |
| (Moran *et al.*, 2014) | 96 | 9,60 |

*Source: Author's elaboration*

Several factors can explain these results. First, research institutes and universities in the USA promote major collaborations between American and foreign researchers, both within and outside their institutions (Gazni *et al.*, 2012). Thus, China, which attributes great relevance to collaborations with foreign countries and within its own country, is attracted to these cooperation opportunities. On the other hand, the collaboration between Australia and New Zealand could be explained by their geographical vicinity and the importance that these two countries attribute to the need to adopt new ESG compliance policies supported by new emerging technologies. Hence between Australian and New Zealand co-authorship among individual researchers, a collaboration between institutions and international collaboration are very common (Benckendorff, 2010). The study also shows that China is a recurring country in terms of most important collaborations among international researchers and has strong connections, especially with some of the G7 countries, particularly Italy, just followed by Japan (He, 2009).

Figure 4. *Countries' collaboration world map*



*Source: Author's elaboration using Bibliometrix*

Table 4. *Most important collaborations among international authors*

| From | To | Frequency |
|---|---|---|
| China | USA | 5 |
| Australia | New Zealand | 3 |
| China | Italy | 3 |
| China | Japan | 3 |
| Italy | Spain | 3 |
| China | United Kingdom | 2 |
| United Kingdom | Canada | 2 |
| United Kingdom | France | 2 |
| United Kingdom | Ireland | 2 |
| United Kingdom | Italy | 2 |

*Source: Author's elaboration*

## *3.1. Source and keywords analysis*

The number of publications related to this subject in international journals represents an important indicator for researchers and authors (Dumay & Cai, 2014). Table 5 shows the analysis of international journals' main sources and publishing interests. As illustrated, the Journal of Cleaner Production is the leading source in this research field, having published nearly 74 articles on the subject. This journal focuses on cleaner production, environmental and sustainability research, and practice, trying to help societies become more sustainable. In second place is situated Technological Forecasting and Social

Change journal, with seven articles published. This represents a key source for all those who want to deal with the methodology and practice of technological forecasting and future studies as planning tools interrelate social, environmental, and technological factors. The third place, with five articles' publications, is held by Accounting, Auditing and Accountability Journal, followed by Business Strategy and the Environment, which has four related publications.

As can be observed from Figure 5, sources' production is grown over time. The growth has started to rise since the early 2000s; previously, there were no publications of articles in this field of research. Journal of Cleaner Production confirms its relevance to this subject area, showing a substantial increase in articles and publications motivating a burgeoning interest in this topic. All the other journals, such as Technological Forecasting and Social Change, Accounting, Auditing and Accountability Journal and Business Strategy and the Environment, have experienced a slightly increasing trend.

Table 5. *Most relevant sources*

| Sources | Articles |
|---|---|
| Journal of Cleaner Production | 74 |
| Technological Forecasting and Social Change | 7 |
| Accounting, Auditing and Accountability Journal | 5 |
| Business Strategy and the Environment | 4 |
| Critical Perspectives on Accounting | 3 |
| Social Responsibility Journal | 3 |
| Sustainability Accounting, Management and Policy Journal | 3 |
| Accounting and Finance | 2 |
| Accounting Education | 2 |
| Accounting Forum | 2 |

*Source: Author's elaboration*

Figure 6 identifies the most frequent keywords that authors believe best represent the content of their paper and their recurring presence in titles, abstracts and keywords used in this research area. The first place is held by the keyword "sustainable development". That occurs because the term "sustainable development" is closely related to the core issue of the study and embodies all the other words contained in the search string. In second place is the keyword "climate change". Despite the search string used in this study considering different kinds of keywords (Massaro *et al.*, 2021), "climate change" is one of the most relevant occurrences and is linked to a unique stream of literature with increasing transversal connections between

research topics. Reference is made, for example, to global warming, greenhouse gases, carbon emissions and earth pollution.

Figure 7 provides another interesting perspective on the keywords' usage. The following thematic map illustrates the evolution of research topics through two variables, on the horizontal axis, the centrality of the research topics (relevance degree) and the vertical axis, the density of their discussion (development degree) (Noyons, 2001).

The map represents different topics organised in four thematic clusters. The lower right-hand side displays some topics, such as sustainable development, decision making and economics, which remain stable over time. At the bottom of the opposite side, we find some emerging relevant research themes, like carbon emissions and mapping. The top right side of the figure contains driving themes, meaning that they have contributed to the growth of this research field, for instance, climate change, life cycle, public policy and sustainability reporting. Lastly, positioned at the centre of the upper part of the map are all those topics that can be considered partly niche arguments but also search drivers, for example, innovation and international trade and some aspects that can be found within the construction industry.

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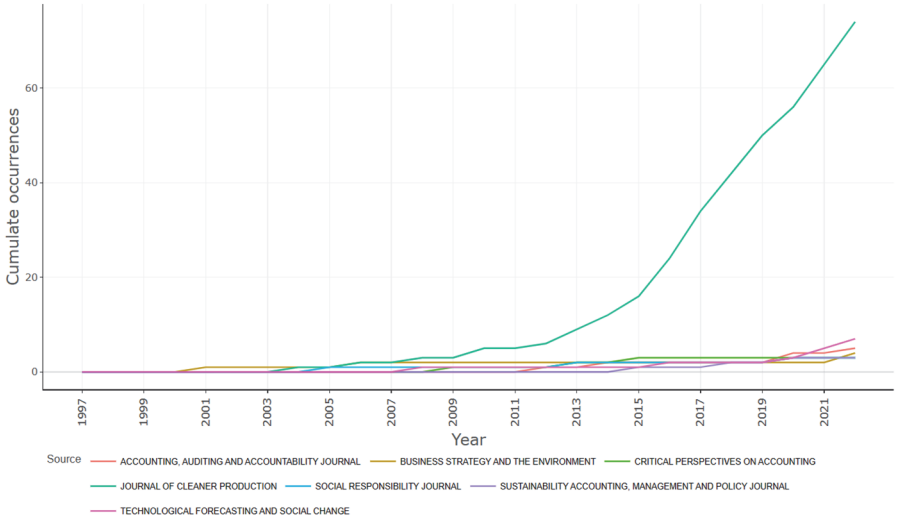
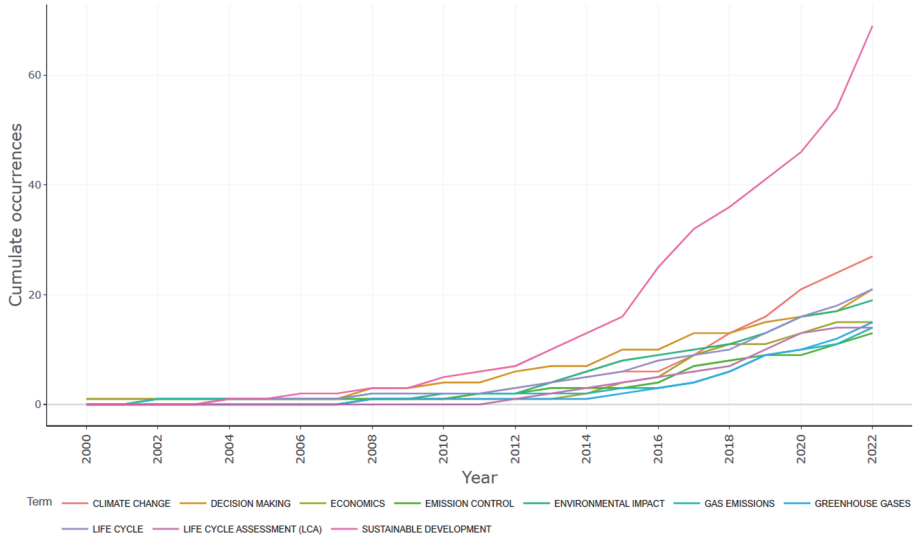
Additionally, to enforce and address RQ2, the next Figure 8 shows the topic dendrogram. The diagram shows the hierarchical relationships between the keywords used in the titles and abstracts by authors ((Aria & Cuccurullo, 2017; Secundo *et al.*, 2020). Considering this representation, obtaining an interpretation and identification of clusters is simpler through a cut of the figure and vertical lines. The figure doesn't represent the perfect level of associations between clusters (Andrews, 2003), but it tries to estimate the approximate number of clusters to enable the discussion of research results. In the conceptual structure map (Figure 9), our study identifies three main research clusters: (1) new emissions control technologies (red area), (2) new sustainability assessment management technologies (blue area), and (3) disruptive energy management technologies (green area).

Figure 5. Sources' production over time



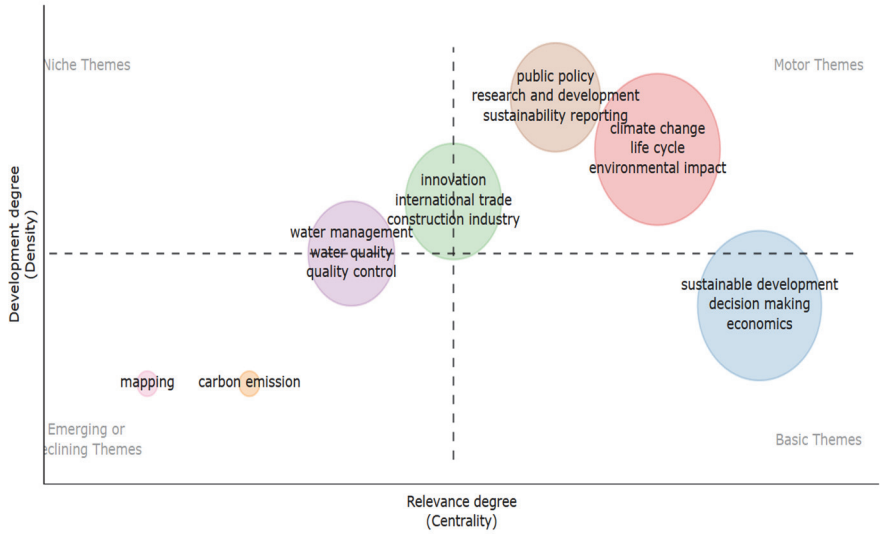

*Source: Author's elaboration using Bibliometrix*

Figure 6. *Words' frequency over time*




*Source: Author's elaboration using Bibliometrix*

Figure 7. *Thematic Map*




*Source: Author's elaboration using Bibliometrix*

### *3.1.1. New emissions control technologies*

The red area focuses on new technologies adopted in emissions control. Indeed, modern technologies are able to check carbon dioxide emissions and result in less use of conventional forms of energy, contributing to greater environmental quality (Zhao *et al.*, 2021). All of these international commitments and countries' efforts have accelerated the introduction of new technologies to achieve rapid and cost-effective emission reduction goals (Lu *et al.*, 2022). It is already known that both governments and private actors are collaborating to relocate investments towards areas with low-carbon technologies (Tao *et al.*, 2022). The most prominent technology under discussion refers to Artificial Intelligence (AI) systems that are widely used in the strategic management processes related to pollutant emissions. AI is projected to be useful in future pollution control and environmental management (Hoang *et al.*, 2022). AI could potentially reduce emissions through optimisation practices (Crawford, 2021). Papers related to climate and sustainability issues demonstrate opportunities for AI to help in decreasing emissions with a focus on quantifying emission reductions. For example, Rolnick *et al.* (2019) summarise current and potential use cases of climate-related machine learning. They describe how it can be a powerful tool in reducing greenhouse gas emissions and helping society adapt to

climate change. Kell *et al.* (2020) illustrate that AI is not directly used to reduce emissions but to demonstrate the optimal low-carbon energy mix for the electricity grid. Furthermore, the analysis shows that the use of AI is particularly common in the agriculture sector because the application of this technology has been found to be the most excellent performer as far as the accuracy and robustness are concerned (Das *et al.*, 2018). This happens because agriculture is a dynamic domain where situations cannot be generalized to find a common solution. Governance frameworks that encourage transparency, accountability, and long-term thinking can support the integration of emissions control strategies into business operations. Robust governance practices ensure that organizations adhere to applicable environmental regulations and standards, minimizing the risk of non-compliance and associated penalties. Effective governance structures also promote transparency and accurate reporting of emissions data to regulatory bodies (Sarpong & Bein, 2020).

### *3.1.2. New sustainability assessment management technologies*

The second strand of literature (blue area) results are linked to technological innovation that can assist sustainability assessment. New technologies can provide the advantage of economic growth and societal benefits and minimize the negative effects on the natural environment by improving, for example, more efficient use of resources and less environmental exploitation. With figure 9, we discover the feasibility of blockchain technology as an infrastructure to improve sustainability assessment management, providing all the information needed for better decision-making in different settings, for instance, in product design, waste treatment, water management and commerce. Over the past few years, numerous studies on blockchain and its applicability have been published. Some of them studied the connection of blockchain applicability with the Internet of Things (IoT) (Conoscenti *et al.*, 2016). Other studies analysed blockchain solutions with big data (Karafiloski & Mishev, 2017). Blockchain technology can be used as a tool to guarantee a secure and reliable decentralized information system to catch and spread all fundamental data that are required to create different sustainability assessment models (Shojaei *et al.*, 2019). The combined use of new emerging technologies also benefits the supply chain side, showing enormous potential for addressing information needs and decreasing sustainability-related uncertainty (Busse *et al.*, 2017). In addition, according to Burkhardt *et al.* (2019), blockchain enables permanent, immutable, and transparent record-keeping of transactions in decentralized systems (Burkhardt

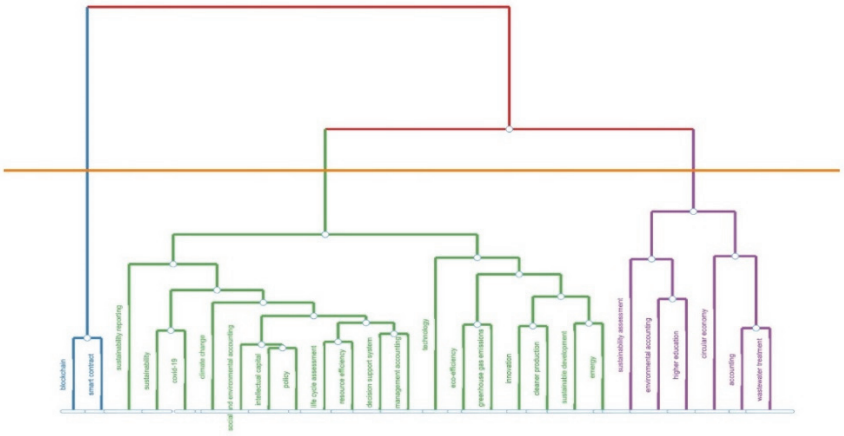
*et al.*, 2019). The blockchain-based system provides financial management for waste collection, aiming at better health and socio-environmental education and people's financial and social inclusion. The (re)cycling of materials within the municipality assists in decreasing the pressure on the environment (MacArthur Foundation, 2019), and the recycled solid waste can be transformed into raw materials for different production chains, contributing to achieving the Sustainable Development Goals (SDGs) set by The Agenda 2030. The governance aspect of ESG involves the establishment of policies, frameworks, and decision-making processes to guide the adoption and implementation of new technologies for sustainability assessment. This includes considerations such as stakeholder engagement, risk assessment, and compliance with regulatory and ethical standards. Effective governance ensures that the adoption of new technologies aligns with the organization's sustainability goals and values (Lin & Qamruzzaman, 2023). New technologies, such as blockchain, Information Technology (IT) and IoT, generate vast amounts of data that are critical for sustainability assessment. Furthermore, it is demonstrated that IT governance frameworks may contribute to the general the implementation of the principles of the good corporate governance (Juiz *et al.*, 2014). Governance frameworks should address data governance issues, including data privacy, security, ownership, and access rights. Robust data governance practices help ensure the integrity, reliability, and ethical use of data in sustainability assessment processes.

### *3.1.3. Disruptive energy management technologies*

The last green cluster deals with new technologies for disruptive energy management. Technological development has long been a key tool in Campo's energy management system (Sagar & Holdren, 2002). Large amounts of data are increasingly accumulated in the energy sector with the continuous application of wireless transmission and cloud computing technologies (Groschopf *et al.*, 2021). For this reason, emerging technologies now play a major role in facing challenges related to the energy system. Digital technologies offer numerous opportunities for improving the construction industry throughout the entire construction life cycle and significant benefits such as cost reductions, production efficiency, improved quality, and speed (Setaki & van Timmeren, 2022). Nowadays, we have access to a wide range of engineering technologies dedicated to increasing electrical energy efficiency. It is important to consider that targeted investments in energy efficiency have the potential to mitigate tensions

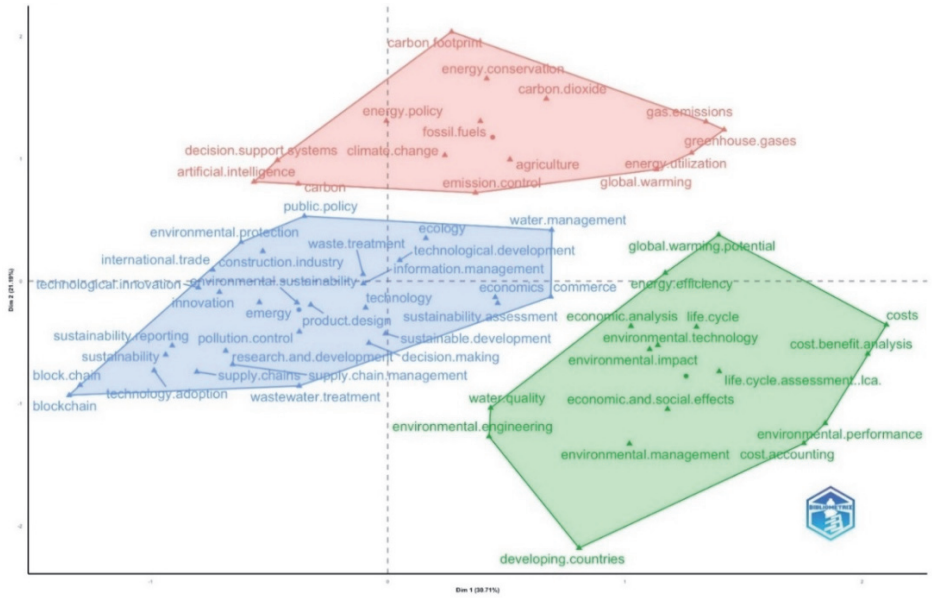
between economic growth objectives and sustainable development commitments (Fowlie & Meeks, 2021). Digital technologies are becoming increasingly important for creating more effective energy efficiency management. Using such new technologies, governments can create data-driven insights into their energy usage and identify areas of improvement (Khaleel *et al.*, 2023). As Saxena *et al.* (2023) suggest, new technologies can help make energy data more accurate and precise by avoiding distortions and facilitating the narrative of non-financial accounting. Regarding good governance practices, they can ensure the efficient and sustainable management of energy resources, improve compliance with environmental regulations, promote fair competition, and protect stakeholders' interests, including consumers and the environment. With the increasing use of digital technologies and data-driven insights in energy management, governance frameworks are needed to address energy data (Yahya & Rafiq, 2020). Effective governance of energy data ensures that data is collected, managed, and utilized responsibly and ethically while also protecting the rights and interests of individuals and organizations.

Figure 8. *Topic dendrogram*




*Source: Author's elaboration using Bibliometrix*

Figure 9. *Conceptual Structure Map*




*Source: Author's elaboration using Bibliometrix*

## 4. Theoretical and practical implications

The study identifies several theoretical and practical implications to provide an orientation to a more sustainable approach for academics and practitioners.

### *4.1 Theoretical implications*

Regarding theoretical implications, this paper extends the results of previous studies that focused on the two areas of new technologies and ESG criteria separately instead of combining them. Indeed, the main objective of this paper is to present and discuss the latest research findings and novelties in emerging technologies focused on ESG compliance. The paper highlights the need for an integrated framework considering the interdependencies and relationships between emerging technologies and ESG aspects. This integration can enhance our understanding of how technological advancements can be leveraged to address environmental, social, and governance challenges.

The theoretical implications of this analysis include deepening our understanding of how technological innovation can act as an enabler for sustainable development, offering insights into the dynamics between innovation, sustainability, and societal well-being.

### *4.2. Practical implications*

Several practical implications were identified, allowing managers and chief technology officers (CTOs) to understand the current connections between technological innovations and economic, social, and environmental aspects within the literature and to visualise new technological frontiers. Another ambitious goal that we sought to pursue was to provide a clear vision of what technologies could be used by companies operating in the various sectors to act sustainably. For example, as shown by Das *et al.* (2018), in the agriculture sector widely use Artificial Intelligence techniques for ESG management and reporting. Gradually very complex problems are being solved with the development of various AI systems able to find specific solutions for each problem.

França *et al.* (2020) show that Blockchain technology is growing worldwide, given its structural characteristics aimed at security and information integrity, without a central management system. Hence, Blockchain should significantly contribute to increasing the quality of life in the typical ESG aspect, such as education, health, environment, social inclusion, and local economy. Moreover, new engineering practices have the potential to guarantee an improved energy-efficient system and to reduce products' life cycle costs (Fowlie & Meeks, 2021).

## 5. Discussion and Conclusion

This section aims to discuss the main findings and conclude the present paper by providing insights, critiques and theoretical and practical implications from the research stream investigated.

The literature review has shown a need for more specific studies highlighting the link between new emerging technologies and the environmental, social and governance criteria. According to Massaro, Dumay, *et al.* (2016) and Paul & Criado (2020), an article based on SRL methodology intends to increase knowledge on a given topic and show future research paths. Thus, our study's main objective is to analyse the role of the new technologies for ESG purposes.

Using a bibliometric analysis, this study aims to decrease bias and increase the research's reliability and rigour by using an objective point of view on the subject matter (Zupic & Čater, 2015). Furthermore, the method adopted in the paper is based on five crucial steps, and a keywords analysis was conducted to select all relevant papers related to the topic.

Analysing the 204 papers selected to conduct this study, we found that the most related articles were published by the Journal of Cleaner Production and these amount to 74 articles, followed by the seven publications in the Technological Forecasting and Social Change and the five publications in the Accounting, Auditing and Accountability Journal. Additionally, the most frequently cited paper is that of Edvinsson (1997), which has 777 citations.

Referring to the geographical distribution of publications, it turned out that the most significant collaborations occurred between China and USA, followed just after the cooperation between Australia and New Zealand.

Another interesting finding emerged from the analysis of publication trends over the years in which we found that, between 2003 and 2011, the flow of scientific publications rose and fell steadily; starting from 2011 onwards, the trend has grown significantly to the present day. Therefore, this result demonstrates an increasing interest of researchers in the subject matter.

The study also includes a keywords analysis that revealed the most frequently used and searched words corresponding to "sustainable development", followed by "climate change". Additionally, through this specific analysis, we identified three main areas of interest related to the topic: new technologies for emissions control, new technologies for sustainability assessment management and new technologies for disruptive energy management. Analysing these three active research streams, we obtained some interesting results; for example, Artificial Intelligence (AI) technology is commonly used to control and strategically manage pollutant emissions. Another important finding is the discovery that blockchain technology is considered an important tool in managing sustainability assessment within companies. Lastly, the study shows that energy efficiency can better balance economic growth and sustainable development.

The study contributes to the state of the field in various ways and frames possible directions for future research but has limitations due to the field's novelty.

The study's limitations are due to the topic's novelty, but it is becoming extremely relevant in recent years. The first limitation can be found in using only the Scopus database to perform a bibliometric analysis of the literature. Secondly, the method adopted relies on the analysis of the keyword to obtain significant results, which may limit the full understanding of the topic and its knowledge. Furthermore, the research considers only peer-reviewed

articles and reviews written in English before 2023 selected within the business, management, and accounting areas. Simultaneously, scholars may consider this study a valuable resource for understanding this research field's state of the art and identifying future analyses.

Finally, the paper proposes future research directions for academia and industry to develop and implement sustainable solutions and increase their compliance with ESG criteria. It would be useful if future studies better emphasise the similarities and differences between practitioners' and scholars' points of view, also using another database to conduct the analysis; this would help capture a broader range of literature and provide a more extensive understanding of the topic. It would also be relevant to conduct comparative analyses between different countries to examine the interpretation of this specific research topic in each area, and to explore the cultural, economic, and regulatory factors that influence the adoption and effectiveness of these technologies in different areas. Future investigations might also consider a wider range of subject areas to include more sectors and research fields in the analysis; this could involve examining the role of new technologies in ESG management across sectors such as healthcare, transportation, and manufacturing, as well as incorporating research fields like environmental science and social sciences. Furthermore, while the current study primarily utilizes quantitative bibliometric analysis, future research can incorporate qualitative research methods to gain a deeper understanding of the perceptions, motivations, and challenges related to adopting and implementing new technologies in ESG management. This could involve interviews, case studies, and surveys with industry practitioners, policymakers, and other relevant stakeholders.

To conclude, it would be particularly interesting if future research would monitor and measure the improvement in the long-term performance of those companies adopting new technologies that enable them to comply with ESG criteria.

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