

IMPACTS OF ENVIRONMENTAL INCENTIVES ON SUSTAINABILITY: RESEARCH PROGRESS, HOTSPOTS, AND FUTURE PERSPECTIVES

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(Received 26th Apr 2025; accepted 16th Jun 2025)

Abstract. Sustainability is fundamental to preserving Earth's delicate ecosystems and ensuring a livable planet for the next generation. A comprehensive understanding of environmental incentives is necessary to develop effective strategies that encourage individuals, industries, and governments to adopt sustainable practices, which in turn promote a cleaner world and minimize environmental problems such as climate change, biodiversity loss, and resource depletion. To effectively address environmental issues and advance toward our shared future objectives, it is crucial to gain a comprehensive understanding of current research patterns concerning environmental incentives and their relationship to sustainability. To gain in-depth understanding on environmental incentives on sustainability, this is the first systematic study to analyze how knowledge is structured, research trends, and emerging topics in this field. This study examined 9,014 documents appearing in the Web of Science Core Collection based on bibliometric analysis aided by visual and social networks and various research metrics. We found that environmental incentives and sustainability research have increased consistently over the past few decades. China ranks first with 606 publications, followed by the United States with 499 publications. In terms of institutions, the University of California System and the Chinese Academy of Sciences ranked first and second, respectively. China's National Natural Science Foundation was the leading funding agency. Environmental management, environmental performance, and sustainable development were prominent keywords. This implies that environmental and balanced practices can contribute to a sustainable environment. This study also highlighted that environmental incentives play a key role in achieving sustainable development goals. It provides a foundation for future research aimed at improving sustainability by implementing environmental incentives.

Keywords: *sustainability, environmental incentives, bibliometric, hotspots, research trends, visualization*

Introduction

Environmental challenges such as land degradation, biodiversity loss, scarcity of water resources, and pollutant emissions have increased from 8,617 to 10,668 million metric tons in China and 5,676 to 4,713 million metric tons in the US. As the largest CO₂ emitters, these countries present a significant concern that must be addressed immediately, as climate change has already affected the planet's environment (Statista Search Department, 2020). The last two centuries have witnessed unprecedented environmental changes, including biodiversity loss, scarcity of water resources,

increasing CO₂ concentrations (from 310 to 380 parts per million since 1950), ocean pollution, and deforestation (Harrison et al., 2018; Ripple et al., 2019).

The emerging research themes during the past five years include sustainable finance, firm value, climate sustainability, green bonds, and climate risk, setting a baseline framework for environmental finance (Tao et al., 2022). Digging deeper into the issue, the blend of historical and contemporary literature suggests that there are three pillars of sustainable development, which are also considered while establishing the Sustainable Development Goals (SDGs) (Scott, 2017). These pillars constitute the social, environmental, and governance dimensions; however, most of the sustainability management and control literature largely focuses on governance issues and their economic implications (Merriman et al., 2016; Tadros and Magnan, 2019a). The concentration of researchers on governance-related environmental performance issues is converted to incentive provisions to reduce carbon emissions (Eccles et al., 2012). Social dilemmas have also attracted the attention of researchers despite growing environmental concerns, while ignoring the significance of the environmental paradigm (Young, 2014; Purvis et al., 2018).

To preserve the contemporary life of societies struggling for a sustainable existence, human-induced impacts on the mediation of climate change have become a necessary takeout to secure the global environmental picture (Conca and Dabelko, 2019). Firms that induce green health and occupational safety have contributed to the implementation of sustainable organizations, thereby increasing employee productivity and safety issues (Schulte and Hser, 2014). The problem of violation of health safety and green supply chains arises because of the inability/lack of willingness of organizations to incorporate sustainable practices (Mirzaei and Shokouhyar, 2022a). Therefore, the emerging need to cater to sustainability to organizations in their supply chain has been calling the attention of researchers in the sustainability and environmental domains.

Since an organization's management is deemed responsible for the ethical, social, and environmental shape of the strategic framework, the power paradigm of an organization plays an important role in determining its sustainable direction (Finkelstein, 1992; Waldman et al., 2006). The locus of control lies with the CEO of the organization, and the personal and professional characteristics of the CEO have a profound influence on the engagement in social and environmental activities (Huang, 2013; Malik et al., 2020). Higher engagement in social activities provides a sense of personal gratification that encourages them to provide value to employees as well as to society (Gond et al., 2017). Another contributing element to CEO engagement in social activities is incentives and awards, and the social image that they achieve through such activities (Fabrizi et al., 2013; Dunbar et al., 2020). Narcissistic CEOs have proven to be more active in social contributions toward sustainability (Petrenko et al., 2016). Since CEO's personalities have a direct link with their social orientation choices, CEOs' insights largely contribute to shaping whether this organization emphasizes planning, incorporating, and implementing social goals (Aguilera et al., 2007). However, executives, to some extent, have the choice to decide how much emphasis should be placed on employees, customers, the environment, or stakeholders, contrary to the sole interests of shareholders (Waldman and Siegel, 2008).

The environmental activity of a firm is subject to a variety of contributing factors at the firm level (Huang, 2019). One of the crucial factors is the incentives offered by the top management team and executives, which contribute to excelling in the environmental dimension (Edmans et al., 2017). The intrinsic motivation of executives

plays an important role in determining their commitment to environmental goals, which is correlated with financial and environmental incentives (Fabrizi et al., 2013). Therefore, the trend toward incentives to achieve environmental governance has led to the most recent debate over pay disparity and environmental incentives. One stream of research supports the positive association between executive pay and environmental performance (Haque, 2017; Adomako et al., 2021). However, another array of studies emphasizes pay disparity, which is a motivating factor for executives to increase their involvement in the long run, focusing on R&D to achieve a sustainable outcome (Lin et al., 2013; Edmans et al., 2017; Patel et al., 2018; Li et al., 2021). Previous literature on social and environmental streams outlines the evidence of monetary and nonmonetary incentives for outstanding environmental performance, such as career growth opportunities, stakeholder trust, personal branding, and enhanced organizational reputation. (Eccles et al., 2012; Fabrizio et al., 2013; Baboukardos, 2018; Shahab et al., 2019; Ren et al., 2020; Nguyen et al., 2021).

According to behavioral psychology and corporate strategy scholars, top management teams, including CEO, are the most significant contributors to emphasizing and entrenching green policy in firm actions, translating them into environmental goals (Adomako et al., 2021). This phenomenon led to an environmental paradigm that dealt with the top management team's motivation to engage in environmental activities. While reviewing the literature on this topic, evidence suggests that executives compromise a firm's long-run environmental objectives over the cost of their short-term financial gains, focusing on selective environmental projects (Bansal and DesJardine, 2014). The reason behind this behavior might be their personal values and individual traits, which determine the extent and scope of their motivation and commitment towards the firm's environmental orientation (Bruno and Lay, 2008). Some of the prominent traits that have captured the attention of scholars in this area of research include CEO power, tenure, and gender (Huang, 2013), educational background (Huang, 2013), political affiliation (Jeong and Kim, 2019), tenure and age (Mammassis and Kostopoulos, 2019), CEO hubris (Tang et al., 2015; Zhang et al., 2018), CEO narcissism (Petrenko et al., 2016), CEO compensation (Fabrizi et al., 2013) and duality (Malik et al., 2020).

CEO compensation and social, environmental performance association and moral practice in this regard, is a recent phenomenon in corporate governance literature paradigm (Fabrizi et al., 2013; Dunbar et al., 2020). Some scholars have studied the relationship between greenhouse gas emissions and the compensation of top management (Haque, 2017). Examples of emphasis on sustainable existence also stem from industry, e.g., Xcel Energy bound its executives incentives partly on environmental performance (based on ecological footprints and emission control objectives), in addition to the financial performance (Mammassis and Kostopoulos, 2019). Hence, the current study aims to enhance the knowledge stream related to the corporate governance theoretical paradigm covering environmental incentives that stimulate environmental performance, based on tournament incentive theory.

Although the available literature reviews on sustainability and environmental domains contribute significantly to enhancing the understanding of environmental performance, environmental disclosure, the extent and scope of greenhouse gas emissions (GHGs), and green technologies to overcome these issues, the abovementioned traditional studies have certain limitations. Traditionally, review articles have dealt with the challenge of comprehensive organization, thorough

representation, and succinct collaboration of relevant literature over a certain subject and quantitative assessment based on carefully designed criteria over a period of time (Roberts et al., 2020). Moreover, the articles in these reviews typically contained a lower number from for instance from 30 to 300 (Snyder, 2019). The possibility of interpretation bias cannot be ignored, as academics have different backgrounds (MacCoun, 1998; Jussim et al., 2015;). In the evolution of a theory or concept over a period, the critical questions hold significant importance like what is the base of evolution of research? What future issues have been considered over time? What are the themes of the most-cited research articles? What are the primary research areas? What is the link between the key themes? (Goyal and Kumar, 2020) These questions indicate the specific (niche) nature of review studies that signify a traditional literature review. Extended knowledge about the research arena can be obtained by conducting an in-depth analysis that considers both quantitative and qualitative aspects (Linnenluecke et al., 2019). Therefore, the need to conduct a systematic literature review on environmental incentives seems to resolve these limitations and address the current problem in a detailed and organized way. Moreover, it would help researchers and academicians to identify the research gaps and areas to emphasize for future research (Snyder, 2019). Modern review methodologies, such as bibliometric review techniques, could be suitable solutions to the traditional issues found in review research (Donthu et al., 2021).

Consequently, research on sustainability model has considered three dimensions; environmental sustainability, economic feasibility and social justice (Purvis et al., 2018; Ranjbari et al., 2021). Therefore, researchers and academicians in sustainability management scholarship are challenged with the incorporation of economic, environmentally and social paradigms into their environmental sustainable well-being and development (Del Río Castro et al., 2021). Environmental challenges and development issues have been used to incorporate “skills and expertise that encompass into Sustainable Development Goals” that include energy, food security, poverty management, health, water, social injustice (Del Río Castro et al., 2021). Clearly, research trends need to be reevaluated and captured within the emergent environment sustainability so that future research incorporates missing strands and expand the understanding of interdisciplinary ideas, concepts, interrelationships, theoretical application and provide deeper insights into the discipline.

To address the underlying research gaps, we employed the bibliometric analysis technique using the Web of Science as to: (1) How long has the discipline of sustainable environment assessment has taken to develop to its current state? (2) Which countries have been more productive and find locus of attention on the sphere of sustainability index? (3) Which countries, regions, organizations and authors have been the most productive in the assessment, application and evaluation of environmental degradation, management and incentives to achieve the goal of sustainable environment? (4) Which publications match the criteria for being considered the most relevant to this research topic? (5) What are contemporary trends and research hotspots to exploring the environmental incentives? (6) How does the distribution of scientific studies on environmental incentives vary among the core and multidisciplinary journals in this research?

The current research provides a unique outlet that identifies the recent developments, current trends in determining environmental incentives and the ignored areas/hotspots that need to be explored in more detail to future research arena. Therefore, the number

of quantitative measures was examined, including the authors that are highly productive and influential, the top institutions involved, the core journals covering this theme, regional contributions and the sphere of this countrywide distribution. The current study provides guidelines for researchers and a systematic review of the relevant core research that needs to be investigated further. Hence, the outcomes of this study pave the way for new perspectives on environmental incentives and their significance in environmental control initiatives.

The study is organized as follows: Section 1 presents an overview of the current sustainability scenario in which environmental incentives play a crucial role in determining the significance of the environmental issues at hand. Section 2 presents the research questions that probe the essence of this study. Section 3 describes the research methodology, followed by the research results, key outcomes, identification of hotspots and relevant publications and the discussion in Section 4. Section 5 presents the conclusions, research gaps, limitations and future research directions, respectively.

Research methodology

A bibliometric analysis can help us to understand how scientific data is evolving and grow over time. Researchers can determine and analyze studies pertaining to subject areas and identify salient features through this approach (Wong et al., 2020; Khalid Mehmood et al., 2023). This offers several avenues of research such as research hotspots, countries and institutional collaboration which can also be revealed through bibliometric analysis, as well as margins of error can be reduced through these kind of special sets of analysis (Vanzetto and Thomé, 2019). By utilizing these analysis, researchers can explore current and future trends in a particular area of interest (Ampese et al., 2022). We have employed Web of Science (WOS) search engine on April 27, 2023, to identify articles published in journals indexed from 1979 to 2022. The study was conducted using the Web of Science Core Collection (WOSCC) database, which is one of the largest and most renowned data sources to retrieve the literature datasets. *Table 1* lists the initial search criteria and refinements used in this study. The aim was to assess the current state of scientific research on environmental incentives on sustainability. The WOSCC is an authoritative and robust search engine that provides access to scientific databases with a variety of interface datasets to analyze the research metrics of particular nature. As a primary objective of this paper, we will analyze key scientific articles to gain a better understanding of the characteristics of significant research, as well as gain insight into how various incentives affect environmental quality and sustainability in different ways.

The current study exploited bibliometric techniques to analyze the research related to SE quantitatively. The researchers of the study rigorously identified all possible keywords. The Boolean Operators connected the shortlisted keywords for query building. The following query was executed in TS (Title, Abstract, Author keywords, and keywords plus) in the WOSCC Advance Search Field on April 27, 2023. TS=("Executive Pay" OR Compensation OR Reward OR Incentive OR Salary) AND TS=("Environmental performance" OR "Environmental reporting" OR "Green performance" OR "Environmental management").

The query resulted in 1438 documents. After excluding 47 records published in 2023, 1391 results were left. The document types of Editorial Materials (6) and Reprints (1) were eliminated. As result, 1384 records were left. After applying these filters, the

data was downloaded in RIS, CSV, and BIB formats. The data was matched for duplication check on title field in Microsoft Excel and also checked with the other fields. Three duplicate records were found and removed from the data. In the end 1381 documents were finally left for analysis. For data analysis, MS Access, MS Excel, BiblioAnalytics, Citespace, VOSviewer software (version 1.6.15), Biblioshiny software, and Power BI were used (Ye et al., 2020). United Kingdom (UK) publications have been categorized among those that are published in Ireland, England, Wales, Northern Ireland, and Scotland. Understanding scientific research trends and identifying research gaps requires a thorough analysis of bibliographic data. A bibliographic analysis identifies the most influential publications and authors, highlights hot spots, and quantifies the influence of scientific research (Wong et al., 2020). As part of our study, bibliometric techniques were employed to systematically review the existing literature on incentives and environmental performance. In order to provide insight into future research directions, it is necessary to identify key research themes and gaps (*Figure 1*).

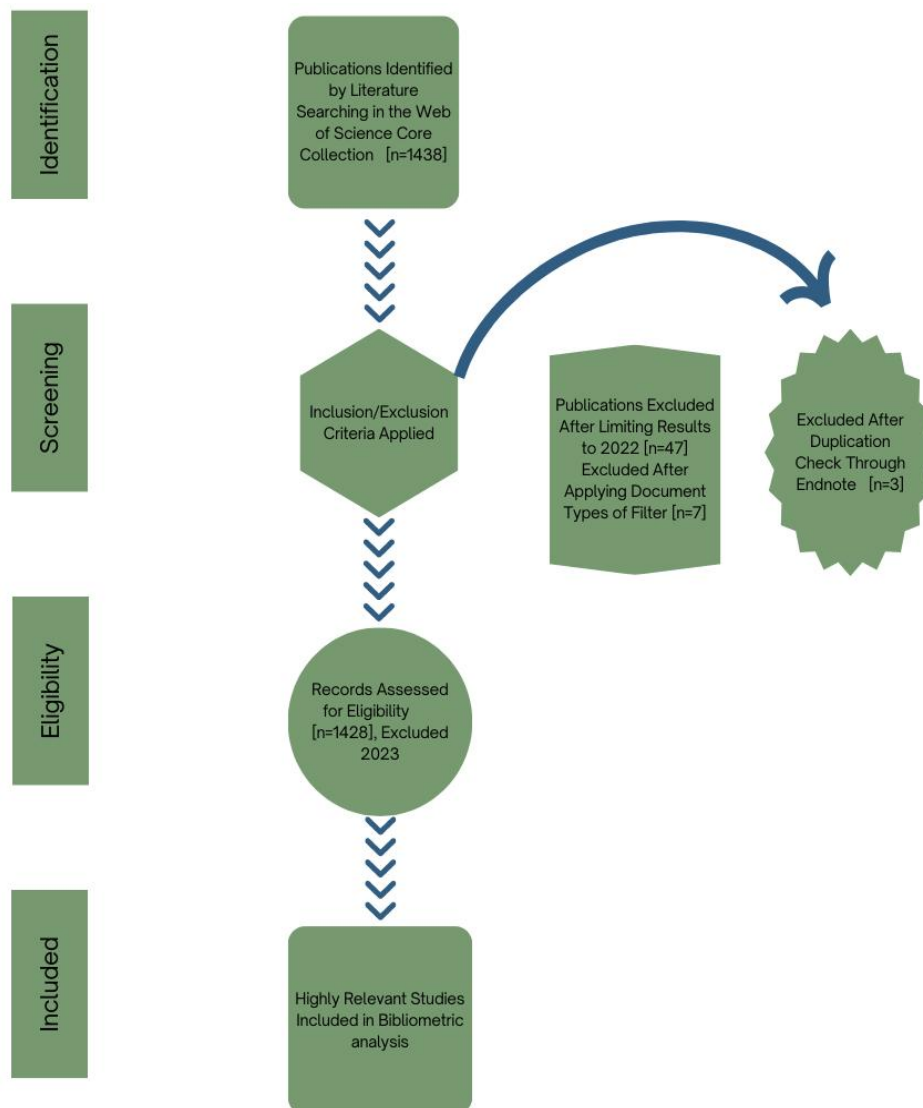


Figure 1. Four phase flow chart of data extraction and filtration process

Table 1. Initial search criteria used for this study

No. of Search	Search criteria for keywords	Period	Database	No. of retrieved documents
Search 1	"Executive Pay" AND "Environmental performance"	1979-2022	WOS core-collection	9014
Search 2	Executive Pay" OR Compensation AND "Environmental performance" OR "Environmental reporting"	1979-2022	WOS core-collection	5149
Search 3	"Executive Pay" OR Compensation OR Reward OR Incentive AND "Environmental performance" OR "Environmental reporting" OR "Green performance"	1979-2022	WOS core-collection	3293
Search 4	Executive Pay" OR Compensation OR Reward OR Incentive OR Salary) AND TS=("Environmental performance" OR "Environmental reporting" OR "Green performance" OR "Environmental management"	1979-2022	WOS core-collection	1438

Results and discussions

Literature evolution and research landscape on environmental incentives and sustainability

Providing rewards for eco-friendly choices is an effective method of driving sustainable practices. The benefits of these activities include economic gains, resource conservation, innovation, pollution reduction, the protection of biodiversity, influencing consumers, and long-term planning. They contribute to a greener future by motivating positive actions. *Figure 2A* illustrates the topic's growth over time. The report covers the period from 1979-2022 and shows how much research has been conducted on Environmental Incentives on Sustainability over that period. Initially, the research was published in 1979, and only two publications appeared in 1991 because environmental awareness and interest in sustainability were still limited at that time. After an interval of one year, the fourth publication was published in 1993. Research has continued without interruption since 1993. It is worth noting that the number of publications remained in the two digits between 1998 and 2017. There were three digits of publications after 2017, with the highest number ($n=206$) in 2022. Based on the citation-wise analysis, 2008 led with 4581 citations, followed by 2012, 2009, and 2011. Research and attention toward environmental issues intensified in 2008 due to critical events. Economic models and systems were reevaluated by the financial crisis of 2007-2008. International cooperation was emphasized at the 2008 United Nations Climate Change Conference. Globalization, technological advances, corporate sustainability shifts, and eco-friendly technologies have all contributed to a rise in demand for comprehensive environmental studies. Researcher and institutions responded to this multidimensional pressure by addressing environmental challenges, raising the importance of environmental studies (Ampah et al., 2021; Khenissi et al., 2022). Recent impactful publications demonstrate the importance of providing incentives for environmental research. It is evident from the high citation scores (1396, 760 in 2021, 2022) that this need is urgent. Recent impactful publications and the growing number of global challenges make it crucial to incentivize environmental action (Khenissi et al., 2022). Investment in environmentally friendly policies shapes a sustainable future,

preserving our planet's ecosystems (Eccles et al., 2012; Zhang et al., 2022; Ali et al., 2023). We must act now to leave a legacy of lasting resilience and responsible stewardship.

In *Figure 2B*, we can see that researchers prefer certain types of documents. Based on the data, the document type “articles” topped the list with 1207 publications, trailing proceedings, and review papers. Additionally, “articles” (n=1207) remained the top document type for citations. The document type “review paper” (n=55) maintained the second position in the citation tally, which was followed by the “proceedings paper” (n=118) at the third position. It is noteworthy that the document type 'review' had the highest research impact (TC/TP), ahead of articles, and proceedings.

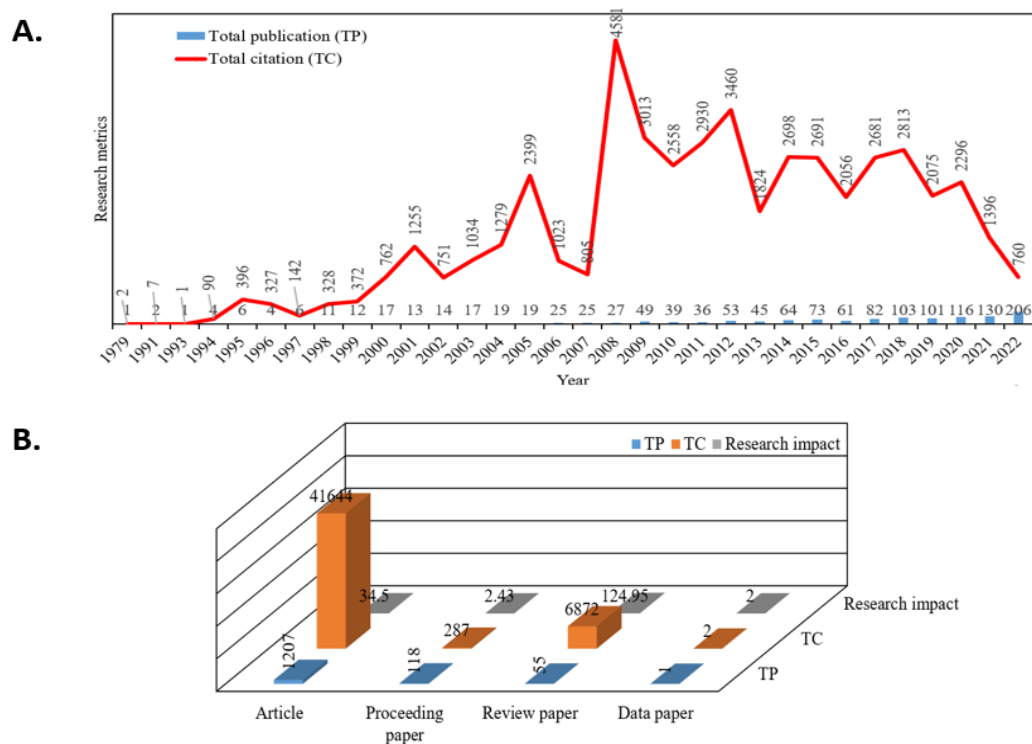


Figure 2. Growth in ES research (A.) and literature landscapes (B.)

Authorship patterns and Prolific scholars in SE research

Figure 3A illustrates the patterns of authorship in the research on this the analysis indicates that there is a wide range of authorship patterns, from a single author up to twenty-three authors. In this research, a two-author pattern was found to be the most frequently published pattern (n=400 publications), followed by three-author and four-author publications. A single-author approach retained a fourth place on the list. The citation analysis shows that the two-author pattern also achieved the highest number of citations, followed by 3 authors, 4 authors, and 1 author. Climate change, pollution, and resource scarcity are urgent environmental challenges which required urgent attention (Ali et al., 2023; Xu et al., 2023). These insights highlight the delicate balance that exists within natural systems that enable life to exist on Earth (Ranjbari et al., 2021). The research has been contributed to by numerous authors who emphasize its significance and identify possibilities for future research. The findings of this study

highlight the critical need for immediate action to protect the environment. To address these issues effectively, scientists, policymakers, and citizens must work together, with the results of research providing valuable guidance. In order to solve environmental problems, it is imperative that we work together.

In *Figure 3B*, we present a list of the top 10 highly productive authors in this field. In terms of publications, the researcher 'Khanna M' emerged as the most productive, followed by 'Wang Y'. Due to an equal number of publications, the researchers 'De Giovanni P', 'Earnhart D', 'Jabbour CJC', and 'Luo I' all maintained the third position. It was determined that three authors were in fourth place because their publications were equal.

There are two types of citations available on the Web of Science, namely, the total local citation score (TLCS) and the total global citation score (TGCS). A list of the most cited authors (locally cited) in this field is presented in *Figure 3C*. A total of 143 local citations have been generated by the author 'Berrone P', followed by 'Khanna M', and the author 'Gomez-mejia LR' with 133 and 107 local citations, respectively. With 91 local citations, Anton Wrq ranked fourth and Lanoie P ranked last with 45 local citations.

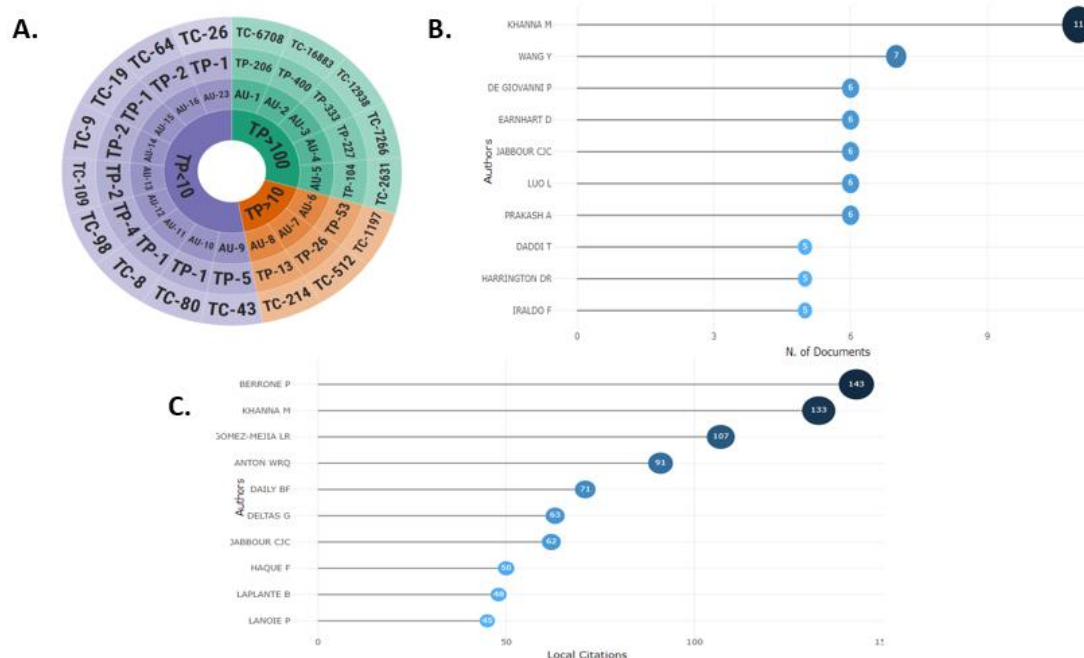


Figure 3. Authorship patterns (A.), Prolific scholars in SE research (B.) and Most locally cited researchers (C.)

Most productive countries and most collaborative countries

Figure 4A shows the countries with the highest productivity. China topped the list with 606 publications, followed by the USA (n=499), Australia (n=213), and Spain (n=119). German publications, on the other hand, remained at the bottom with 84. In addition, the figure shows how the countries rank in terms of citations. With 14841 citations, the USA ranked first, followed by China (n=4730), Spain (n=4441), and Canada (n=4433). Among the top countries with the most citations, Australia ranked

fifth with 3434, Italy with 1245 citations was sixth in front of France with 1061, Malaysia with 668, and Brazil with 2016. In terms of citations, the USA and China are the clear leaders, reflecting the relative importance of each country's research quality. In order to address climate change and promote sustainability, both the United States and China have taken significant environmental initiatives (Zhang et al., 2022; Xu et al., 2023). It has been reported that the United States has rejoined the Paris Agreement and is introducing the Clean Power Plan, whereas China is heavily investing in renewable energy, encouraging electric vehicle adoption, and focusing on afforestation (Ali et al., 2023). The Chinese government has pledged to achieve carbon neutrality by the year 2060 and to peak carbon emissions by 2030 (Mehmood et al., 2022). This will require changes in the energy, transportation, and manufacturing sectors. Chinese businesses have been encouraged to reduce their carbon footprint and adopt cleaner practices by introducing a national carbon market (Ali et al., 2023). As such, they are setting the direction for the global research agenda.

Figure 4B shows the countries that have contributed the most research to the topic with their partner countries. It is evident from the figure that China, the United States, the United Kingdom, Australia, and Spain are highly collaborative countries. As illustrated in the figure, they collaborate as well as with other countries. Furthermore, these countries appear to be the driving force behind the growth of research on the topic, setting the stage for further global collaboration.

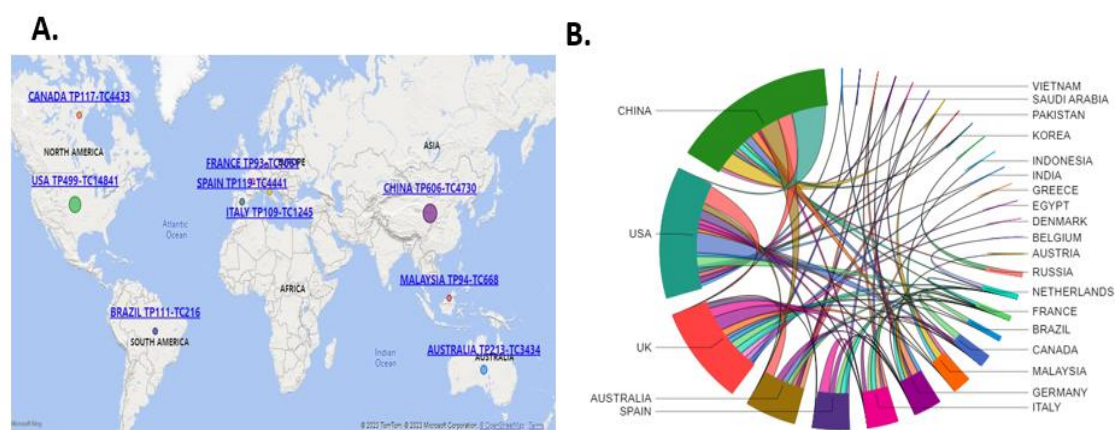


Figure 4. Most productive countries (A.) and Country collaboration (B.)

Most productive affiliations and funding agencies

Based on publications, Table 2A illustrates the leading ten most productive affiliations on the topic. With the highest number of publications, the University of California System was ranked first, followed by the Chinese Academy of Sciences, Wageningen University & Research, and the University of London. The table also includes an analysis of the citations related to the top 10 highly productive affiliations. After analyzing the citations associated with the publications on the topic, the 'University of California System' ranked at the top, followed by the 'University of Illinois System' and the 'Shanghai Jiao Tong University'. Additionally, the table presents the impact (TC/TP).

Table 2. Most productive affiliations (publications ordered by TP) (A.) Most productive affiliations (publications ordered by citations) (B.) and Most funding agencies (C.)

A.

	Affiliation	TP	TC	C/P
	University of California System	26	4031	155
	Chinese Academy of Sciences	16	460	28.75
	Wageningen University & Research	15	493	32.87
	University of London	14	396	28.29
	Tsinghua University	13	278	21.38
	University of Illinois System	13	1144	88
	Shanghai Jiao Tong University	13	672	51.69
	Universiti Teknologi Malaysia	12	219	18.25
	Swiss Federal Institutes of Technology Domain	12	528	44
	UDICE-French Research Universities	11	186	16.91

B.

	Affiliation	TC	TP	C/P
	University of California System	4031	26	155.04
	University of Navarra	2047	7	292.43
	University of Western Ontario	1340	1	1340
	Western Sydney University	1146	8	143.25
	University of Illinois System	1144	13	88
	IE University	1085	2	542.5
	New Mexico State University	1041	3	347
	Texas A&M University System	995	4	248.75
	State University System of Florida	969	10	96.9
	Universite De Montreal	963	8	120.38

C.

	Funding Agencies	Record Count
	National Natural Science Foundation of China	100
	Fundamental Research Funds For The Central Universities	27
	European Commission	22
	UK Research Innovation	19
	Conselho Nacional De Desenvolvimento Cientifico E Tecnologico	11
	National Social Science Foundation of China	11
	Economic Social Research Council	10
	National Social Science Fund of China	10
	Australian Research Council	9
	Coordenacao De Aperfeicoamento De Pessoal De Nivel Superior Capes	9

According to the citation data presented in *Table 2B.*, the top 10 affiliations with the highest citations are listed. It is also worth noting that the affiliation 'University of California System' remains at the top in terms of citations (4031). Despite contributing only seven publications, the University of Navarra managed to achieve the second-highest number of citations (2047) among the top ten highly productive affiliations. In spite of having only one publication, the University of Western Ontario secured 1340 citations. In addition, Western Sydney University was able to maintain the fourth position in the citation rankings (1146) despite contributing only eight publications. Additionally, the table illustrates how affiliations affect their publications. This shows that research quality is more important than the quantity of publications. The institutions with fewer publications still managed to gain attention and recognition through their research quality. Thus, it is more important to focus on the quality of research than the quantity. Based on the research on the topic, *Table 2C* lists the top ten funding agencies. As a result of funding the most studies on this topic, 'The National Natural Science Foundation of China (NSFC)' ranked at the top of the analysis. Second and third place was occupied by the 'Fundamental Research Funds for the Central Universities, China' and the 'European Commission'. Additionally, 'UK Research Innovation' remained in fourth position. However, due to their equal funding of projects, the agencies 'Conselho Nacional De Desenvolvimento Cientifico E Tecnologico' and 'The National Social Science Foundation of China' both remained in fifth place. Accordingly, the major research funding in China explains why the country was ranked as the top country for research publications and contributed significantly to sustainable development. This reflects the Chinese government's commitment to investing in research and development, which has had a positive effect on China's research output and helped propel the country forward in terms of sustainability.

Highly productive sources

An important aspect of the bibliometric analysis of environmental incentives and sustainability is to determine the distribution of journals so that future researchers have an idea of where to focus their efforts. A summary of the highly productive sources for publishing research on this topic can be found in *Figure 5*. Research on the topic was most productively published in the Journal of Cleaner Production (IF₂₀₂₃ 11.1), followed by the Journal of Environmental Management (IF₂₀₂₃ 8.3), and the Journal of Business Strategy and the Environment (IF₂₀₂₃ 13.4). Ecological Economics (IF₂₀₂₃ 7.0) and Sustainability (IF₂₀₂₃ 3.9) remained at the fourth and fifth spots, respectively. The Journal of Business Ethics (IF₂₀₂₃ 6.1) and the International Journal of Production Economics (IF₂₀₂₃ 12.0) are the next contenders. The eighth position is jointly held by the European Journal of Operational Research (IF₂₀₂₃ 6.4), Environmental Science and Pollution Research (IF₂₀₂₃ 5.8), and Energy Policy (IF₂₀₂₃ 9.0). By analyzing the similarities between articles, such as when two articles refer to the same source, a bibliographic coupling analysis can reveal clustering patterns. Using the visualization of the analysis results (Khalid Mehmood et al., 2023). This shows a strong interest in the topics of sustainability and environmental economics, as well as in the area of business ethics. Additionally, the fact that three journals shared the eighth spot indicates that the field is highly competitive. This demonstrates the importance of sustainability and environmental economics, as well as business ethics, and highlights the cut-throat competition in the sector.

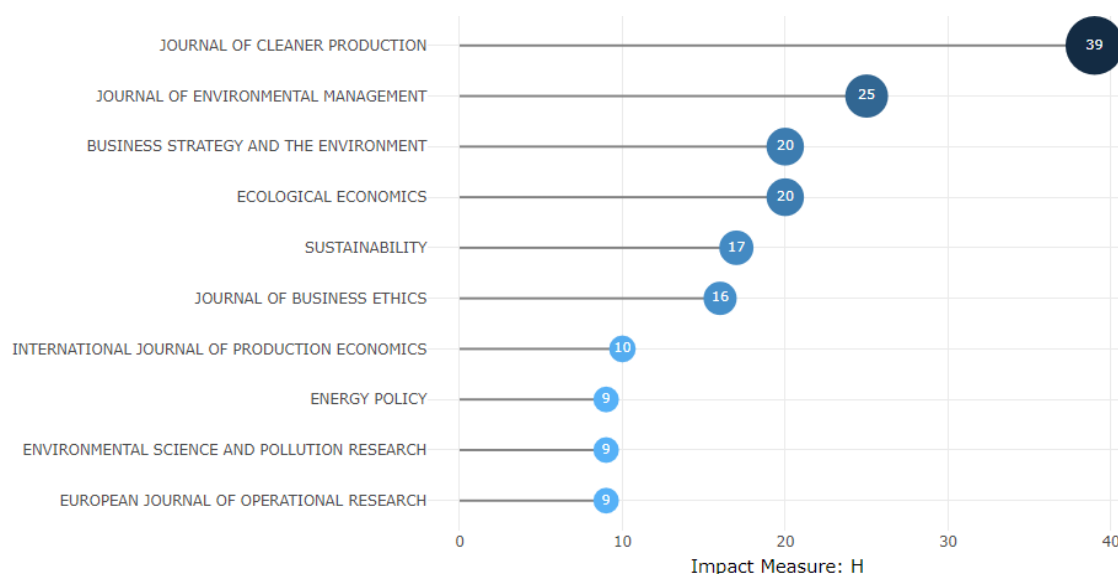


Figure 5. Highly productive sources

Emerging research trends and evolution of author keywords

Figure 6A illustrates how the researchers have focused their research on the topic over time. From left to right, the figure displays publication years at the bottom and clusters of documents related to the research at the top. The list of topics in the figure is arranged vertically, starting with the most recent and ending with the oldest. There are several topics at the top of the figure, including corporate governance, green human

resources management, and corporate social responsibility, and other topics at the bottom of the figure, including environmental management and environmental policy. A number of keywords were used, such as 'environmental management' and 'environmental performance'. Over the course of the literature review, sustainability topics have shifted from environmental management to corporate governance (Gerged et al., 2021). Accordingly, sustainability research is increasingly focusing on organizational issues instead of environmental issues (Ali et al., 2023). As a result of this shift, many organizations have realized that sustainability is not just about managing the environment, but also about managing themselves and their practices to ensure long-term success (Xu et al., 2023). Increasingly volatile global markets require organizations to adopt more sustainable practices (Ali et al., 2023). Therefore, organizational sustainability has become a critical component of maintaining a competitive edge for organizations, as it is essential for long-term success and continuity of operations. It's like planting a tree: in the short term, it may not seem like much, but with enough nurturing, time, and care, it can grow into a powerful and resilient organism that will outlast even the most turbulent of storms. Rafi (2022) reports that, while 90% of executives believe sustainability is important, only 60% of organizations have sustainability strategies.

In *Figure 6B*, we can see the evolution of keywords in the author's research on this topic over time. The frequently used keywords are shown with the corresponding periods. Each node's size is depicted by the amount of time the keyword has been used, and the direction in which the keywords have evolved. Only keywords associated with evolved keywords are shown in the figure. From left to right, the keywords' evolutionary paths with their corresponding periods are shown. It evolved from 'adaptive management' to 'environmental performance' to 'circular economy' (Di Vaio et al., 2023). Several keywords have evolved into the term 'environmental performance', including 'environmental management', 'climate change', 'financial performance', and 'sustainability' (Kordsachia et al., 2021). In addition, the figure illustrates the evolution paths of the themes over time. The figure also highlights the importance of environmental performance, as it is the final keyword in the evolutionary cycle (Huang, 2019; Nguyen et al., 2021). In the figure, it can be seen how organizations have become increasingly focused on environmental performance (Ampah et al., 2021). Additionally, it illustrates the increasing importance placed on environmental performance by businesses (Ali et al., 2023). It is a positive sign of progress and will contribute to the implementation of more sustainable practices in the future (Kordsachia et al., 2021). Environmental performance cannot be ignored by companies and must be prioritized in their operations (Nguyen et al., 2021). It is an important step in the direction of a more sustainable future. It is encouraging to see this shift in focus toward environmental performance, which is indicative of a progress-oriented mindset, which will ultimately lead to a more sustainable future. The importance of environmental performance in a company's operations should thus be prioritized and viewed as a necessity. In a sense, this change is like planting a garden. It requires dedication and hard work at the beginning. Over time, however, a garden will flourish with consistent care, creating a sustainable environment that can be enjoyed for a long time to come. A sustainable future can be achieved by committing to environmental performance (Ali et al., 2023).

A word cloud map of the authors' keywords can be seen in *Figure 6C*. With the help of the map, it is possible to determine the frequency of keywords used by the authors based on their size. Researchers in this field frequently refer to "environmental

management", "environmental performance", "sustainable development", "sustainable development", "incentives", and "compensation" as keywords (Edmans et al., 2017; Tadros and Magnan, 2019a; Roberts et al., 2020; Ali et al., 2023). Additionally, the graph displays some of the most commonly used author keywords. A graph illustrating the author's research work allows the reader to quickly grasp the main themes the author explores in his or her work. Upon reviewing the graph, readers have the opportunity to determine which topics have been extensively explored and which topics remain to be explored. Therefore, they are able to make better-informed decisions regarding the areas of research that they should pursue. Apart from identifying potential collaborative opportunities, the graph also allows readers to identify areas where their research can be most beneficial. In this way, potential collaborations or research areas may be identified that might be beneficial in the future.

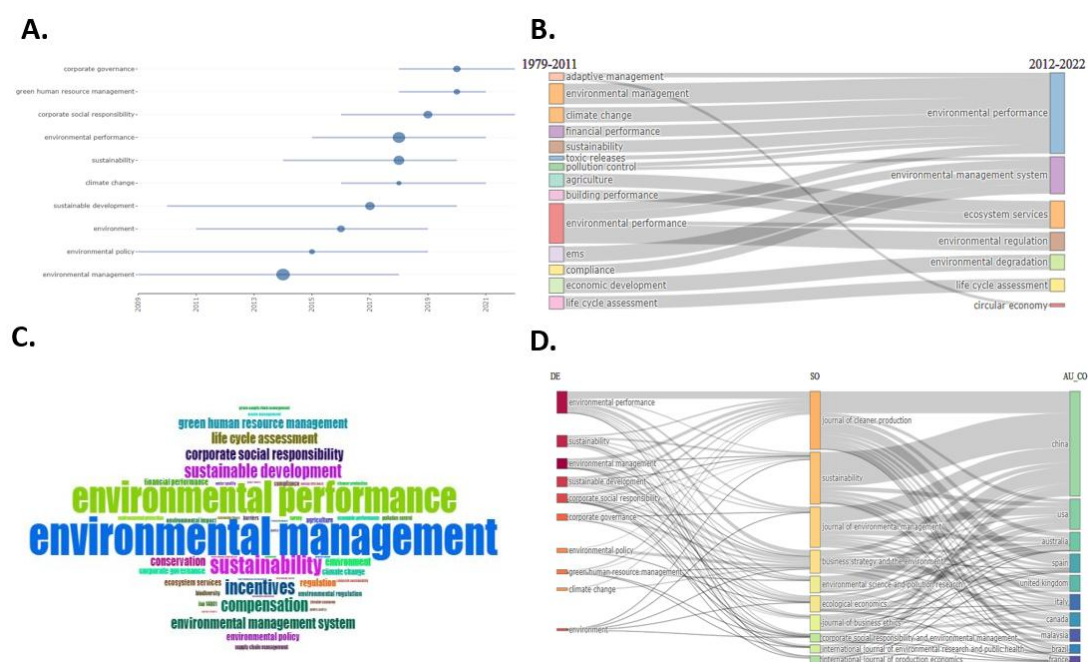


Figure 6. Topic trends (A.), Evolution of author keywords (B.), Word cloud of author keywords (C.) and Three-field plot (author keywords-source-country) (D.)

Figure 6D illustrates the author's keywords on the left, the source in the center, and the country of the author on the right. Keywords are grouped according to authorship country and source of publication. The author can be found in the 'Journal of cleaner production' under the keyword 'environmental performance', and he hails from a country called China (Gao et al., 2022). On the graph one can see that the remaining keywords, the sources, and the countries of the authors are prominent. These trends indicate that environmental performance research has a clear focus. Moreover, it indicates the growing importance of environmental issues in the academic community. This data can be used to inform future research and policy decisions. A growing awareness of environmental issues may explain the increase in environmental performance research, as indicated by the data (Ali et al., 2023). This trend may have an impact on the development of policy and future research priorities. Research sources and the countries of origin of the authors can also provide valuable information regarding potential

collaborations and how different countries approach environmental issues. The different sources of environmental research are necessary to gain a deeper understanding of the environmental challenges facing different countries. As a result of analyzing this data, we will be able to determine potential cross-border collaborations and benchmarking opportunities, as well as inform policy development and research priorities.

Meso and mirco citation topics

In Web of Science, topics are divided into three categories based on citations and citing relationships, namely macrotopics, mesotopics, and microtopics. *Fig. 7A* presents a word cloud illustrating Meso citation topics with five words or more in their titles. Meso citations are most prominent in the areas of management, sustainability science, supply chain and logistics, forest management, and agricultural policy. By analyzing this word cloud, you will be able to identify trends and popular topics in the field as well as identify the most prominent meso topics in the Web of Science. Moreover, it assists researchers in identifying which topics are being studied most thoroughly, and which topics may require further investigation. As a result, researchers are able to gain a deeper understanding of the current state of the discipline by studying the word cloud, which allows them to focus their research on areas that have not yet been adequately addressed. To get an idea of the weather in a particular area, one can read the weather report. In order to make informed decisions, one should be aware of the temperature, humidity, and precipitation levels of the current climate in order to make informed choices.

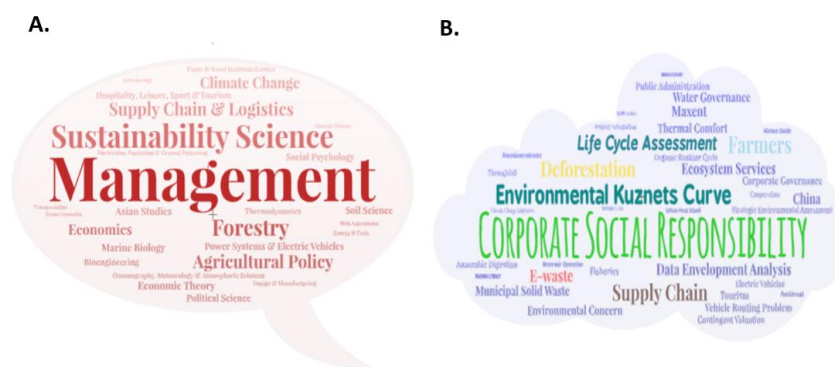


Figure 7. Meso Citation Topics (minimum 5 and more words) (A.) and Micro Citation Topics (minimum 5 and more words) (B.)

On the other hand, *Figure 7B* displays a word cloud of topics with a minimum of five words. As can be seen in the graph, the Micro citation topics 'Supply Chain', 'Life Cycle Assessment', 'Corporate Social Responsibility', and 'Environmental Kuznets Curve' appear most prevalent. Furthermore, as the size of the words reflects the prevalence of each topic, this word cloud indicates the amount of research being conducted in these areas. There is a strong emphasis on continuing to develop sustainable solutions, which determines the potential of sustainability as a major field of study. Research trends in sustainability can be compared to the movement of a snowball down a mountain that continues to gain mass and momentum. Research and resources are increasingly being devoted to sustainable development as people realize its importance.

Potentials and way forward of environmental incentives on sustainability

A variety of factors have contributed to the emergence of environmental challenges worldwide. CO₂ emissions contribute significantly to environmental degradation. In the decade from 2010 to 2020, China's CO₂ emissions increased from 8,617 to 10,668 (in millions of metric tons) and the US's from 5,676 to 4,713 (mmm) (Cabernard et al., 2022; Zhang et al., 2022; Habiba et al., 2023). Air and water pollution, habitat destruction, and climate change have all been caused by this growth in CO₂ emissions. Climate change has resulted from the increase in CO₂ emissions, which has inadvertently affected the climate of the planet. Climate change mitigation strategies have been investigated and proposed by researchers (Kazemifar, 2022). In order to address environmental challenges, sustainable development is becoming increasingly important.

Governance, environmental, and social pillars make up sustainable development. According to Del Río Castro et al. (2021), the SDGs are based on these four pillars. It is noteworthy, however, that the majority of literature on sustainability management, on the other hand, has focused mainly on governance and economic implications, leaving out the environmental impacts (Tadros and Magnan, 2019b). Incentives to reduce carbon emissions have become the focus of research on governance-related issues (Edmans et al., 2017; Dunbar et al., 2020; Ali et al., 2023).

In order to overcome environmental challenges, a multidimensional approach is required that takes into account all sustainability pillars. While researchers have focused on social dilemmas in spite of environmental concerns (Purvis et al., 2018), environmental paradigms have been overlooked. Developing sustainable supply chains is essential for organizations that want to achieve environmental goals. As Mirzaei and Shokouhyar (2022b) assert, the lack of willingness or ability of organizations to incorporate sustainable practices causes health safety violations and green supply chain breaches.

It is important for the CEO to engage in social and environmental activities in order to shape the sustainability direction of the organization. It is the CEO's responsibility to ensure that the strategic framework is ethical, social, and environmentally sound. A critical aspect of determining the sustainable direction of an organization is the power paradigm, which is outlined by Finkelstein (1992); Waldman et al. (2006). There is a direct connection between the CEO and the engagement of social and environmental activities, and the CEO's personality and professional characteristics greatly influence the level of engagement. A study conducted by Huang (2013) and Malik et al. (2020) found that employees who are more engaged in social activities are more likely to feel a sense of personal satisfaction, which in turn encourages them to be of service to the organization and society in general. Clearly, leadership influences how employees view themselves and their work. Engaging executives in social impact initiatives can create a culture of engagement that benefits organizations and society.

CEOs are also engaged in social activities because of incentives and awards (Ali et al., 2023). Incentives and awards motivate CEOs to engage in social contributions to sustainability, according to Dunbar et al. (2020); and Fabrizi et al. (2013). They are motivated to be gratified by the realization that they have the ability to positively impact society, which ultimately has a positive impact on the sustainability of the company (Ali et al., 2023). This sense of gratification leads to increased morale and motivation within the company, which in turn leads to increased productivity and efficiency. Additionally, it also helps to improve the company's reputation in the public eye, which can be

beneficial in the long run. Therefore, this results in a virtuous cycle that can have tangible benefits for the company in terms of improved sustainability, morale, productivity, efficiency, and reputation.

Incentives may include financial rewards, recognition, or social status. Through tangible and intangible incentives, they encourage CEOs to engage in social and environmental activities. According to Hu et al. (2022), and found a positive relationship. In a developing country, there is a positive correlation between CEO incentives and corporate environmental responsibility in China. Ali et al. (2023) found that CEO incentives and corporate environmental responsibility are positively related. Meanwhile, Dunbar et al. (2020) In Pakistan, they found mixed results when examining CEO incentives for environmental disclosure. A number of studies have demonstrated that CEO incentives are linked to improved corporate environmental performance and environmental responsibility. However, other studies have demonstrated that this relationship is much more complex, dependent on a variety of contextual factors.

Additionally, the involvement of the CEO of a company in social and environmental activities may affect employees as well as other stakeholders. As indicated by Boulouta and Pitelis (2014) the CEO's personal values and beliefs have a significant influence on employees' attitudes and behavior regarding social and environmental issues. The impact of this will likely be significant on the company's sustainability culture and performance in general. It has been suggested in recent literature that CEO incentives may play an important role in promoting engagement with environmental and sustainable development projects. It is therefore important for organizations to take into account the implications of linking CEO incentives to sustainability goals. As such, this could be an effective method of ensuring that sustainability initiatives are adequately supported and implemented throughout the organization.

According to several studies, CEOs prioritize environmental and social concerns in their strategic planning when there are incentives to adopt sustainable practices (Hu et al., 2022). Moreover, CEO incentives may enhance transparency and accountability in relation to the environment and social practices of a company (Liu et al., 2019). Various studies have demonstrated that incentive programs designed to encourage CEOs to follow sustainable practices have improved environmental performance and minimized environmental risks (Liu et al., 2019; Ali et al., 2023). Incentives that encourage sustainability have proven to be effective tools for enticing CEOs to invest in sustainable innovations, resulting in positive results for the organization.

There are, however, concerns regarding the effectiveness of CEO incentives in promoting sustainable practices. There is evidence that CEO incentives contribute to short-termism and neglect long-term environmental goals (Hu et al., 2022). In addition, it is possible that a CEO incentive program would prove ineffective in industries where environmental performance is difficult to measure (Merriman et al., 2016). The effect of CEO incentives on sustainability engagement has been argued by some researchers. In spite of the fact that incentives can promote short-term environmental performance, they may ultimately lead to decreased sustainability over time (Merriman et al., 2016; Tadros and Magnan, 2019b). Incentives may lead to conflict between CEOs and other stakeholders, resulting in unintended consequences. Hu et al. (2022) further argue that company size, ownership structure, and industry affect CEO incentives and their impact on environmental performance. Therefore, organizations should be aware of how their incentives can lead to sustainable or unsustainable outcomes in order to develop environmental policies that are effective and beneficial. In order to develop effective

environmental strategies, it is essential to understand how incentives are structured and their potential outcomes. A substantial contribution to sustainable development and environmental initiatives can be made by incentive programs for CEOs, according to the literature. There is a need for further research to better understand how CEO incentives promote sustainability and their limitations.

In conclusion, one of the most important factors in determining the sustainability direction of a company is the involvement of the CEO in social and environmental activities. Based on the CEO's personal and professional characteristics, incentives and awards, and personal values and beliefs, there is a profound impact on his or her engagement in social and environmental activities. The CEOs of organizations should be encouraged to engage in social and environmental activities as part of their overall sustainability strategy. It is possible to accomplish this by providing incentives and resources, like financial rewards. Additionally, CEOs must have the necessary skills and capabilities to play a significant role in driving sustainability initiatives. In addition, sustainable behavior should be rewarded and celebrated in organizations. Leaders must set clear expectations and lead by example to create a successful sustainability strategy. According to Fela Duratoye, a Nigerian motivational speaker, leadership is a relationship of service that inspires people to grow and makes the world a better place.”

Conclusions, limitations, and future directions

An extensive bibliometric analysis based on 9014 documents retrieved from the WoSCC database between 1979 and 2022. It has revealed that the research on environmental incentives on sustainability is evolving consistently and dynamics of research play significant role in shaping the various aspects of sustainable science and management. This study illustrated that Chinese and American scholars emerge as leading with 606 publications and 499 publications respectively. In terms of institutions University of California System has ranked first with 26 publications and 4031 citations followed by the Chinese Academy of Sciences with 16 publications and 460 citations. The majority of the articles appeared in journals including the Journal of Clean Production (39), the Journal of Environmental Management (25), and the Journal of Business Strategy and the Environment and Ecological Economics (20).

This study pinpointed key research hotspots, including environmental management, performance, and sustainable development. It has become apparent that corporate strategies, executive behavior, and environmental incentives have an intricate interplay that shapes organizational ecological stewardship. By identifying research gaps and exploring unexplored territories, this analysis provides a roadmap for future research, inviting researchers to delve deeper and contribute to the ever-evolving conversation about environmental incentives. The role of environmental incentives has taken center stage in the global community as it faces pressing environmental challenges. Besides enriching our understanding of this critical relationship, this study also inspires action. The study will provide an insight to embark on a transformational journey which that thrives economically, socially, and ecologically and will create synergy between environmental incentives and sustainability.

There are, however, limitations to the analysis: only documents with specific keywords were included, potentially excluding relevant documents. In addition, the analysis was restricted to the WoSCC database only. Researchers should investigate other databases, such as Scopus, Google Scholar, and CNKI, in the future. In addition,

because citation counts and publication numbers change rapidly, bibliometric studies have a short reference span. The importance of staying current with evolving research cannot be overstated.

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APPENDIX

Table A1. Contributions of environmental incentives paradigm into sustainability literature

Reference Study	Region/Country (Time Period)	Main Constructs	Technique/ Method(s)	Contribution(s)	Subject Category	Author keywords	Limitations /Recommendations
Goldsmith and Basak (2001)	USA	Environmental diligence; Environmental stewardship performance	Analytical Model Development	Using a Principal-Agent Model, modelling and analysis of the Environmental Performance Indicators (EPI) problem, but the elaboration of several corrective strategies firms might employ	Environmental Science	Principal-agent; Environmental performance indicators; Output uncertainty; Environmental risk; Compliance; Incentives.	Models can be extended to incorporate multiple agents & focus on peer monitoring and address moral hazard concerns.
Eccles et al. (2012)	Cross-country/Multinational organizations (794 firms) (2007-2010)	Monetary and Non-monetary Incentives; Carbon Emissions	Quantitative; Panel Techniques	The monetary incentives were found to be associated with higher carbon emissions. While, nonmonetary incentives tend to be associated with lower carbon Emission.	Business Management & Accounting	Pay; Environmental Performance; Incentive Provision; Carbon Emissions.	Longer time to analyze the incentives and their eventual impact would be fruitful for researchers.
Merriman et al. (2016)	USA (n=400) (Cross-sectional)	Employee Incentives; Environmental objective; Financial objectives	Quasi-experimental design- <i>post hoc</i> qualitative analysis	The insights into employee individual level analysis and organizational sustainability incorporation.	Managerial Psychology	Performance management; Human resource strategies; Incentives.	The role of implicit norms for financial performance must be considered when investigating employee engagement in sustainability efforts of the organization.

Reference Study	Region/Country (Time Period)	Main Constructs	Technique/ Method(s)	Contribution(s)	Subject Category	Author keywords	Limitations /Recommendations
Tadros and Magnan (2019a)	USA (78 firms) (1997-2010)	Environmental Performance; Economic and Legitimacy Factors	Content Analysis	Evidence of Environmental performance moderating the effect of economic and legitimacy incentives on firms' propensity to provide proprietary environmental disclosure, with both sets of incentives being influential is provided.	Business Management & Accounting	Content analysis; Environment; Voluntary disclosure; Legitimization.	Subjectivity concern in measurement of environmental disclosure; Reliance on printed media employed for society and interest group pressure; Timeliness of reported sample firms information. The impact of social media could be considered for future studies.
Ampah et al. (2021)	54 Countries including USA, UK, China. (583 articles) (2000-2020)	Alternative marine fuels; Shipping Emissions; Maritime Transport; Decarbonization	Bibliometric Technique/ Web of Science Analysis	This study outlines the rising issue of shipping emissions in maritime sector, while providing suggestions for alternative marine fuels and identifying hotspots of current research.	Energy (Renewable Energy, Sustainability and the Environment)	Alternative marine fuels; International maritime organization; Maritime transport; Shipping emissions; Decarbonization; Research trend.	Research community may consider the potential of different alternative fuels e.g. methanol, ammonia, and hydrogen fuels as a replacement to conventional marine fuels to limit the shipping emissions from an environmental, technical, and economic perspective.
K. Mehmood et al. (2022)	Global/ Multiple countries (2003 articles) (2020-2021)	COVID 19; Air Pollution; SARS-COV-2	Bibliometric Technique/ Web of Science Analysis	Identification of framework, challenges, and future perspective as of COVID-19	Environmental Science & Health	COVID-19; Air pollution; Bibliometric analysis; Web of Science.	Baseline to extend research in the domain of environmental and health sciences to estimate the potential impact of

Reference Study	Region/Country (Time Period)	Main Constructs	Technique/ Method(s)	Contribution(s)	Subject Category	Author keywords	Limitations /Recommendations
				repercussions, covering the period between January 01, 2020, and June 21, 2021			the COVID-19 pandemic on air pollution.
Tamala, Maramag, Simeon, and Ignacio (2022)	Multiple Countries (312 articles) (1994-2021)	Oil and Gas Production; Climate Change; Sustainable Development	Bibliometric/ Scopus	Analysis of trends and future research with respect to sustainable oil and gas production from 1994 to 2021.	Engineering Science	Sustainable oil and gas production; Petroleum industry; Bibliometric analysis; VOS viewer; Sustainable development.	As more engineering bottlenecks in the current and future hydrocarbon production arise other than safety concerns, environmental degradation, climate change, and social acceptance, significant scientific efforts would be more vital to unravel them.
Kordsachia et al. (2021b)	Europe (921 firms) (2008-2017)	Institutional Investors; Responsible Investment; Environmental Performance	Quantitative; Panel Data Analysis	The study emphasizes the interrelationship between organizations and their relationships with the natural environment, including institutional equity ownership (content-driven vs time-driven) towards greener practices on a corporate level using agency theory.	Business, Management and Accounting	Sustainable investors; Institutional investors; Investment horizon; Corporate social responsibility; Environmental performance.	To reach the goal of climate neutral economy by 2050, researchers might consider European regulation regarding green finance to ensure the better awareness of institutional investors.

Reference Study	Region/Country (Time Period)	Main Constructs	Technique/ Method(s)	Contribution(s)	Subject Category	Author keywords	Limitations /Recommendations
Khenissi et al. (2022)	French companies listed on the SBF 120 index (2014-2019)	CEO incentive compensation and financial performance	Empirical analysis	The inclusion of CSR criteria in compensation contracts improves environmental, societal and governance performance	Finance Research Letters	CEO incentive pays; CSR criteria; CSR performance; Financial performance	limitation of this study is that it is conducted with data from only France and, therefore, the results can be at most generalized to French companies

Highlights

- Bibliometric analysis was conducted between 1979 and 2022.
- The literature was visualized using advanced indicators and tools.
- Research hotspots and highly impactful articles were discussed.
- China and the United States lead research trends on environmental incentives and sustainability.
- China and USA are highly productive and National Natural Science Foundation of China is the major funding agency.

Graphical abstract

