Original Article

Environmental Management In Times Of Pandemic. A Bibliometric Study

Dennis Arias-Chávez[1*], Yrene Cecilia Uribe-Hernández[2], Raúl Alberto Rengifo Lozano[3]

[1*]Universidad Continental, Arequipa, PERÚ, ORCID Https://Orcid.Org/0000-0003-1500-8366
[2]Universidad Nacional De Cañete, PERÚ, ORCID Https://Orcid.Org/0000-0001-5893-9262
[3]Universidad Nacional Mayor De San Marcos, PERÚ, ORCID Https://Orcid.Org/0000-0002-6545-6442

***Corresponding Author: - Dennis Arias-Chávez**

[*]Universidad Continental, Arequipa, PERÚ, ORCID Https://Orcid.Org/0000-0003-1500-8366
Doi: 10.47750/pnr.2022.13.S02.71

Abstract

The study aims to characterize the global scientific production on environmental management at the global level in the Scopus and Web of Science, between the months of January 2020 to March 2022. A retrospective descriptive bibliometric analysis was carried out. 1133 documents from the Web of database were analyzed. Science and 1687 from Scopus, drawn from 565 and 771 sources respectively. Regarding the number of authors, Scopus presents 6067 and Web of Science, 4043. The rate of collaboration between authors is slightly lower in Web of Science (3.82) compared to 3.95 from Scopus. The most cited article is "Green innovation and environmental performance: The role of green transformational leadership and green human resource management ", the author with the most papers on the subject is Yi Zhang, IOP Conference Series: Earth And Environmental magazine Science stands out as the medium with the largest number of publications related to environmental management, the type of scientific document that stands out the most is the original article, as for the country with the largest number of publications on environmental management, China stands out. With regard to collaboration between countries, China and Pakistan stand out in the case of Web of Science and China and the United States in the case of Scopus . It is concluded that, in recent years, scientific production on environmental management has shown an accelerated increase motivated by the dramatic changes generated by the COVID-19 pandemic.

Keywords: Scientometrics; scientific production, environmental management.

INTRODUCTION

Environmental conservation has become a very common topic of discussion around the world. The rapid growth of the population and unplanned urbanization is causing several environmental crises on the planet, which has increased concern about its impact on all areas of life [1] . Economic development without ecological considerations causes the environmental crisis. As a result, the quality of life of the present generation and the future generation gradually decreases. This fact demands a response from the companies that are expected to implement and execute efficient environmental management systems. 23

Environmental management is nothing more than a tool to recover the quality of nature. It is an organized approach to overseeing the environmental affairs of an organization. The main objective of this management process is the minimization of waste. An effective environmental management process reduces carbon emissions, prevents pollution, helps process all waste, and encourages smart use of energy and resources. However, many companies are not prepared to deal with the environmental problems generated by their work, as well as with compliance with the environmental laws of the countries where they work. [4]

It is important to highlight that the problem of environmental pollution has worsened in recent years, raising concerns about environmental protection. Humanity has also begun to give importance to the issues of education and environmental management and the development and application of knowledge and clean technologies, since it has understood that poor environmental management can lacerate and disappear some of the natural conditions that help survival. [5]. Environmental protection lies in the control of environmental pollution, the prevention of pollution deterioration, the protection of human beings, and the auxiliary improvement of environmental quality. [6]

In the field of environmental management, there are various bibliometric studies that have contributed to measuring and determining production on this topic worldwide. For example, the study by Letunovska et al. [7] who analyzed the scientific production on environmental management and social marketing; the study by Luna et al. [8] on academic publications in journals with the theme of environmental management; the research by Xue et al. [9] on the evolution of process safety and environmental protection; the study by Schaltegger et al. [10] on environmental management accounting; His et al. [11] and its study on carbon emissions and environmental management; Zhu & Wang 's study [12] on collaborative networks and thematic trends in purchasing and supply management research for environmental sustainability; Xu et al. [13] and his study on one of the most relevant engineering journals on environmental management; Pereira et al. [14] and his study on the evolution of environmental sustainability; Kurtulus & Tatar [15] and their study of articles on environmental education

published between 1973 and 2019; Akerlof et al. [16] and his study on the growth and disciplinary convergence of environmental communication; the study by Akbari et al. [17] on research into sustainable technologies; the study by Cortes et al. [18] on innovation for sustainability in the Global South; Lopera-Perez et al. [19] and his study on international scientific production on environmental education; and Nájera-Sánchez et al. [20,24-44] and its mapping of the conceptual structure of environmental management.

An increasing number of applied disciplines are using evidence-based frameworks to review and disseminate the effectiveness of environmental management and policy interventions. The reason is the increase and accessibility to the best available evidence in scientific databases, providing a more efficient and less biased platform for decision making. There are significant conservation benefits to using such a framework, but more literature reviews must be undertaken and disseminated by the scientific community before the full benefits can be realized. The emergence in science of databases such as Scopus and Web of Science has made the acquisition of large volumes of bibliometric data relatively easy, and the emergence of bibliometric software such as Gephi , Leximancer , and VOSviewer allow the analysis of such data in a very pragmatic way, which has sparked academic interest in the analysis. bibliometric in recent times. Twenty-oneTo date, there is no evidence of the dynamics of global research on environmental management in the context of this pandemic. Currently there is a need to know the bibliometric impact of the pandemic through the volume of information published on the methods, advances and proposals in environmental management that allows an overview of the countries that are producing this literature and the potential impact generated. For the pandemic. For this reason, this research aims to characterize the global scientific production on environmental management between the months of January 2020 and March 2022, in two of the most important scientific databases in the world: Scopus and Web of Science (hereinafter WoS).

MATERIAL AND METHODS

A retrospective descriptive bibliometric analysis of the world scientific production on environmental management in the context of the COVID-19 pandemic (2020-2021) was carried out. The Scopus and WoS databases were considered, calculating their bibliometric indicators through the R bibliometrix software and the managers of these databases. Regarding the search strategies, the formula (TITLE (management) AND TITLE (environmental) AND PUBYEAR > 2019 was used, adapting it to the characteristics of each software and database. The results were reviewed individually, forming a final sample of 1,133 results in WoS and 1,687 in Scopus. The number of selected articles comply with being an adequate result of the proposed search. The data obtained was exported in RIS and CSV formats to be later processed and analyzed with the help of the Bibliometrix R and Vos Viewer software.

The bibliometric indicators considered for the research were based on general information about the data, authors and collaboration of authors. The results are presented in tables and figures in order to respond to the stated objective.

RESULTS

Table 1 shows the information regarding the main bibliometric indicators extracted from the Bibliometrix software on environmental management. A total of 1,133 documents were obtained from the WoS database and 1,687 from Scopus, extracted from 565 and 771 sources, respectively, generating a very similar citation average (1.37 for WoS and 1.33 for Scopus). The average number of citations per document is also similar, being 3,637 (WoS) and 3,353 (Scopus).

Regarding the number of authors, Scopus presents 6067 of which 191 authors appear as unique to the article, and WoS 4043 of which 102 authors appear as unique. The rest of the documents have multiple authors (in both databases they are close to four). The collaboration index between authors is slightly lower in WoS (3.82) compared to 3.95 in Scopus. Finally, WoS presents 2,805 keywords and Scopus, 7,068.

Table 1. Bibliometric information on environmental management in Scopus and WoS (2020-2022)

Description	WoS	Scopus
Main information about the data		
Sources	565	771
documents	1133	1687
Average years since publication	1.37	1.33
Average number of citations per document	3,637	3,253
Average number of citations per year per document	1,512	1,274
References	1	1
Authors		
Authors	4043	6067
Author appearances	4474	6812
Single Author Document Authors	100	153
Authors of multi-author documents	3943	5914
Author Collaboration		
Single Author Documents	102	191
Documents by Author	0.28	0.278
Authors per document	3.57	3.6
Co-authors per document	3.95	4.04
Collaboration Index	3.82	3.95
document content		
Keywords (IDs)	2805	7068
Author keywords (DE)	4079	4882

Source: Bibliometrix R (2022)

When analyzing world scientific production by year (see figure 1), it is observed that the Scopus database has a higher production (in 2020, 1,147 scientific documents were produced and in 2021, 1,373 documents).
At the beginning of March 2022, the production was 209 scientific documents (56 documents published in WoS and 153 in Scopus), which allows forecasting a growth in production for this year, compared to 2021, if the current trend is maintained.

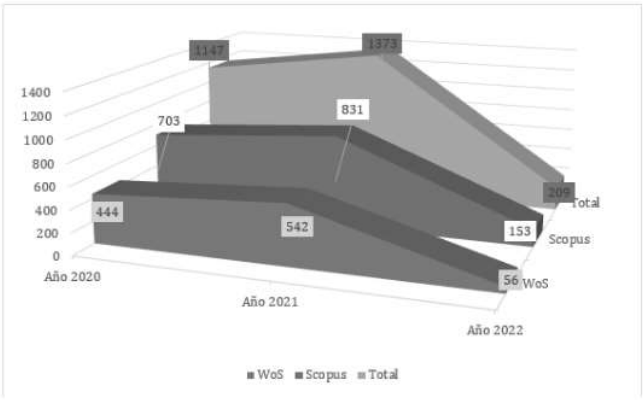

Figure 1. Annual production of scientific documents by database.
Source: Bibliometrix R (2022)

Table 2 shows the list of the most cited articles in the WoS and Scopus databases . The study by Sanjay Kumar Singh, Manlio Del Giudice , Roberto Chierici and Domenico Graziano stands out, entitled "Green innovation and environmental performance: The role of green transformational leadership and green human resource management ", the same one that received 205 citations in WoS and 241 in Scopus since its appearance in January 2020, in the journal Technological Forecasting and Social Change from the Elsevier publishing house (Cite Score 2020 impact indices of 12.1 and a 2020 SJR of 2,226).

Table 2. Five most cited articles of scientific production on environmental management in Scopus and WoS

			Quotes			
No.	Authors	Qualification	Scopus	wow		Source
1	Singh SK, Giudice MD, Chierici R, Graziano D.	Green innovation and environmental performance: The role of green transformational leadership and green human resource management	241	205	2020	Technological Forecasting and Social Change
2	Wang L.,Wu W.-M.,Bolan N.S.,Tsang D.C.W.,Li Y.,Qin M., Hou D.	Environmental fate, toxicity and risk management strategies of nanoplastics in the environment: Current status and future perspectives	88	74	2020	Biological Conservation
3	Arslan, M; Xu, B and El-Din, MG.	Transmission of SARS-CoV-2 via fecal-oral and aerosols-borne routes: Environmental dynamics and implications for wastewater management in underprivileged societies	70	68	2020	Science of the Total Environment
4	Anwar N., H. Mahmood N.H., Yusliza M.Y.,Ramayah T.,Noor Faezah J..,Khalid W.	Green Human Resource Management for organisational citizenship behaviour towards the environment and environmental performance on a university campus	68	57	2020	Journal of Cleaner Production
5	Yu, W., Chavez, R., Feng, M., Wong, C.Y., Fynes, B.	Green human resource management and environmental cooperation: An ability-motivation-opportunity and contingency perspective	64	53	2020	International Journal of Production Economics

Table 3 shows the authors with the largest number of publications related to environmental management. The Chinese Yi Zhang stands out from the list with 13 publications in Scopus and 9 in WoS , followed by Wang Z with 8 articles published in WoS and 10 in Scopus .

Table 3. Authors with the largest number of publications related to environmental management in the WoS and Scopus databases

WoS		Scopus	
ZhangY.	9	ZhangY.	13
Wang Z	8	Wang Y	eleven
Daddi T	6	Wang Z	10
Liu H	6	Zhang Z	9
Zhang W	6	Chen, X.	8

Regarding the journals with the highest production on environmental management (see table 4), it stands out IOP Conference Series: Earth And Environmental Science from IOP Publishing Ltd., which features 96 Scopus publications . While in WoS , the magazine Sustainability (Switzerland) from the publisher MDPI AG stands out with 74 publications.

Table 4. Journals with the largest number of publications related to environmental management in the WoS and Scopus databases

Scopus		WoS	
IOP Conference Series: Earth and Environmental Science	96	Sustainability (Switzerland)	74
Sustainability (Switzerland)	75	Journal of cleaner production	56
Journal Of Cleaner Production	59	Journal of environmental management	40
Journal Of Environmental Management	55	Science of the total environment	27
E3S Web Of Conferences	48	Business strategy and the environment	24

Regarding the types of research (see table 5), in the two databases analyzed, original scientific articles predominate (911 in WoS and 1184 in Scopus), followed by retractions.

Table 5. Types of publications in WoS and Scopus

WoS		Scopus	
Article	911	Article	1184
Early Access	87	Retracted publication	237
Review	77	news item	112
Editorial	27	procedures paper	46
book review	8	Editorial	42

Regarding the original countries of the investigations (see table 6 and figure 2) in both databases, China stands out with 702 articles in Scopus and 633 in WoS , followed by the United States with 434 and 529 publications, respectively.

Table 9. Countries of origin of publications in WoS and Scopus

WoS		Scopus	
China	633	China	702
United States	434	United States	529
India	220	Australia	245
Brazil	205	Brazil	240
Indonesia	203	United Kingdom	211

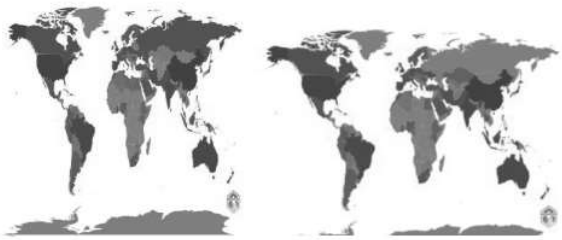

Figure 2. Scientific production by country during 2020-2022 in the WoS and Scopus databases

Regarding the co-occurrence network analysis of the keywords in the Scopus database (see figure 3), the creation of 6 clusters, 742 items, 37,625 links and a total link strength of 66,754 is observed.

Cluster 1 (red) that is born from *enviromental management* with 629 occurrences; cluster 2 (green) with *China* and 76 occurrences; cluster 3 (blue) with *waste management* and 143 occurrences; cluster 4 (yellow) with *nonhuman* and 57 occurrences; cluster 5 (violet) with *climate change* and 72 occurrences; and cluster 6 (light blue) with *article* and 158 occurrences.

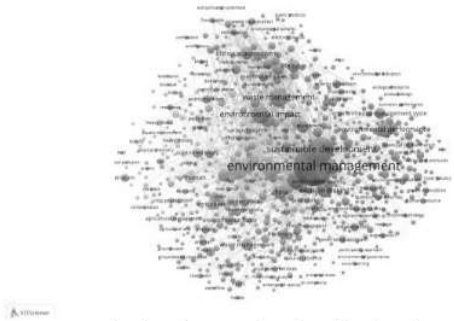

Figure 3 .Analysis of network visualization in Scopus .

The thematic map of Scopus (see figure 4) shows as motor themes to *environmental knowledge* , *students* and *pre-environmental behaviour* . Regarding the basic topics , *education* , *education research* , *gender* , *environmental education* and *environment education research* . Regarding emerging or disappearing themes, n *children* , *higher* stands out

education and environment activism . Finally, regarding highly specialized or niche topics, *coemissions , augmented reality , outdoor learning , distance learning* and *art* [icle].

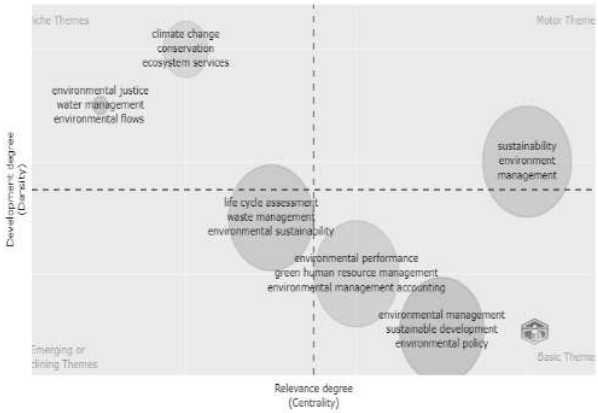

Figure 4. Scopus Thematic Map.

Regarding the co-occurrence network analysis of the keywords in the WoS database (see figure 5), the creation of 6 clusters, 320 items, 7180 links and a total link strength of 12237 is observed.

Cluster 1 (red) that is born from *framework* with 61 occurrences; cluster 2 (green) with *sustainability* and 145 occurrences; cluster 3 (blue) with *systems* and 58 occurrences; cluster 4 (yellow) with *innovation* and 47 occurrences; cluster 5 (purple) with *environment* and 24 occurrences; and cluster 6 (light blue) with *methodology* and 5 occurrences.

WoS thematic map (see figure 6) shows *conservation* as motor themes, *green* and *universities.* Regarding the basic topics, *intervention, knowledge* and *sustainable stand out. Development.* Regarding emerging or disappearing themes, *sustainability, health* and *schools stand out.* Finally, regarding highly specialized or niche topics, *performance, climate-change, coemissions , economic-growth* and *engagement stand out. Classroom.*

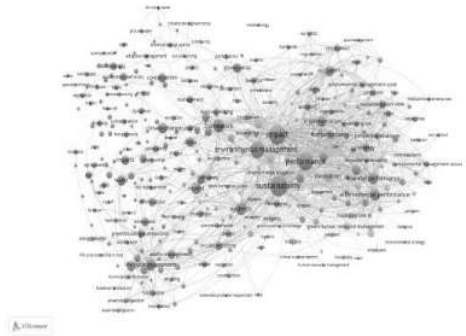

Figure 5. Analysis of network visualization in WoS .

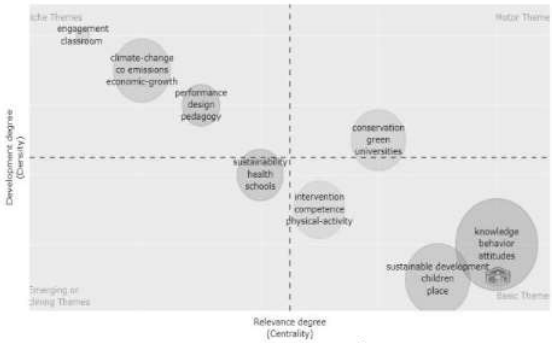

Figure 6. WoS Thematic Map.

Finally, graph 7 shows the collaboration map between countries. It shows that, in the case of WoS , the 27 collaborations were between China and Pakistan; while for the case of Scopus , the 28 collaborations were between China and the United States.

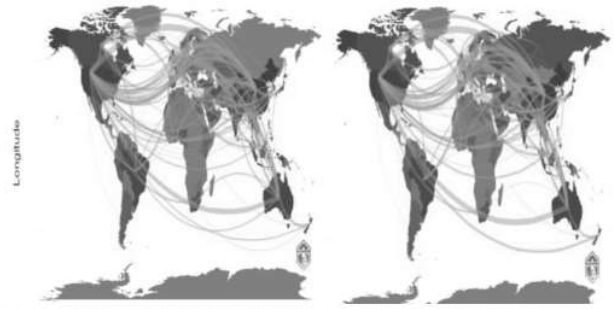

Figure 7. Maps of collaboration between countries. WoS and Scopus

DISCUSSION

The results show that Scopus stands as the database that brings together the largest scientific production on environmental management. Now, in 2021, the indexed documents on the subject in this database increased compared to 2020. In this year, 1,147 scientific documents were produced and in 2021, 1,373 documents. In addition, a growth trend was observed that will also be reflected in the year 2022. This result coincides with that found by Letun ovska et al. [7], who tracked a significant set of publications related to environmental management. For the authors, the number of articles published between 2017-2020 show that the popularity of the topic has been growing (which is also highlighted in the present study). Further analysis of the frequency distribution of publishing activity by subperiod confirms the leading indicators from the 2011-2016 subperiod when the topic gradually gained considerable popularity.

The increase in the number of scientific papers is due to the growing popularity of the concept of the environment. In this sense, Luna et al. [8] conclude that, regarding the temporal analysis of the publications, there is evidence of a constant interest in the topic of environmental management, a result that also coincides with what was found by Xue et al. [9] who found a tendency to increase publications on environmental management. The present study worked with 1,133 documents from the WoS database and 1,687 from Scopus , extracted from 565 and 771 sources, respectively, generating a very similar citation average (1.37 for WoS and 1.33 for Scopus). The average number of citations per document is also similar, being 3,637 for WoS and 3,353 for Scopus. Schaltegger et al. [10] worked with a database containing 814 (396 of them published in academic journals) publications in English, German and French with a publication date prior to 2012. Su et al. [eleven] elaborated an analysis involving 274 articles after a rigorous selection. Zhu & Wang [12] evaluated 371 peer-reviewed articles published between 1998 and 2017, while Xu et al. [13] analyzed 403 articles published in the Journal of Environment Engineering and Landscape Management (JEELM) from 2007 to 2019. As can be seen, the present study covered a greater number of articles, which makes what was found more significant.

Regarding the number of authors, Scopus presents 6067 of which 191 authors appear as unique to the article, while WoS presents 4043 of which 102 authors appear as unique. The rest of the documents have multiple authors. The collaboration index between authors is slightly lower in WoS (3.82) compared to 3.95 in Scopus. In this line, Pereira et al. [14] retrieved 339 articles, making a total of 756 authors and 11,765.

As for the article with the highest number of citations, it stands out the study by Sanjay Kumar Singh, Manlio Del Giudice , Roberto Chierici and Domenico Graziano, entitled "Green innovation and environmental performance: The role of green transformational leadership and green human resource management ", the same one that received 205 citations in WoS and 241 in Scopus since its appearance in January 2020, in the Technological magazine Forecasting and Social Change. While the most prolific author is the Chinese Yi Zhang with 13 publications in Scopus and 9 in WoS . In the investigation by Schaltegger et al. [10] highlights the article by Mathews "25 years social and environmental accounts research: is there a silver jubilee to celebrate ?", being its most prolific author Stefan Schaltegger with 28 publications. Zhu & Wang [12] Sarkis , Zhu, Vachon and Klassen stand out as THE most productive authors .

It is important to know which are the top journals that publish research on environmental management in order to understand current trends and lines of research. In this study, the journal "IOP Conference Series: Earth And Environmental Science ", with 96 publications in Scopus. In WoS , the magazine " Sustainability " (Switzerland) stands out with 74 publications. It should be noted that in the research by Kurtulus & Tatar [15] , the highest numbers of articles accessed were published in " Environmental Education Research " (f = 241), "International Research in Geographical and Environmental Education " (f = 145) and " Sustainability " (Switzerland) (f = 122). For Letunovska et al. [7] the main magazines are "Social Marketing Quarterly " (Sage Publishing, USA), " Journal of Social Marketing" (Emerald Group Publishing, UK) and " Journal of Nonprofit and Public Sector Marketing" (Taylor & Francis, UK), while for Akerlof et al. [16] the main magazines were " Environmental Communication ", "JCOM" and " Science Communication ". Finally, Akbari et al. [17] highlights the "Revista de Tecnología Química y Biotecnología" as the most dominant medium, with 154 citations per document.

The importance of environmental management is determined by the need to manage human activities related to damage to the environment. The introduction of environmental management has a positive impact in reducing the anthropogenic

load on the environment and contributes to the harmonization of the relationship between man and nature [22] . For this reason, it is important to know the countries with the highest production of research. The study highlights China with 702 articles in Scopus and 633 in WoS . On the other hand, Cortés et al. [18] China's undisputed leadership in overall production and setting of the research agenda on environmental management are also highlighted in their study. However, countries like India, Mexico and Nigeria are more efficient or impactful on the subject. For Xue et al. [9] , China (with 678 publications and 9,615 total citations) and the United Kingdom (with 476 publications and 7,517 total citations) have been at the forefront and play the predominant roles in environmental issues.

In the two databases analyzed, original scientific articles predominate (514 in WoS and 510 in Scopus). This result coincides with what was found by Lopera-Pérez et al. [19] who conclude that original articles are the most common type of publication, representing 92.02% of all documents analyzed.

Regarding the co-occurrence network analysis of the keywords in the Scopus database, the creation of 6 clusters, 742 items, 37,625 links and a total link strength of 66,754 is observed. In the study by Cortés et al. [18] stand out in Group 1 (green): *Knowledge management;* group 2 (orange): *Biotechnology for agriculture;* group 3 (purple): *Project Governance* and *Energy Management in China* . In the case of Xue et al. [9] , who worked with the WoS base , the blue group concentrated mainly on environmental protection theories and techniques. The red group focused on methodologies and models for process safety and risk management in the chemical and process industries. The yellow group focused on inherent safety and hazard identification and assessment in the chemical and process industries, and the green group focused on loss prevention in the process industries.
Finally, the thematic map of WoS shows *conservation as motor themes, green* and *universities*. The Scopus thematic map shows how motor and *environmental themes knowledge, students* and *pre-environmental behaviour* . Nájera-Sánchez et al. twenty i identified and explained six themes: *green/environmental, resource-based vision, management, performance, corporate social responsibility,* and *quality management.*

This study highlights the importance of bibliometric studies for the treatment of information on scientific production and research related to environmental management. Based on the WoS and Scopus databases, the main characteristics regarding publications, authors, sources, collaboration between authors and countries, and network analysis have been extracted, using bibliometric techniques from the publications made in the last two years. A constant increase in scientific production is corroborated. This is based on the accelerated development of environmental management and its relationship with human development, being in a period of dramatic changes enhanced by the COVID-19 pandemic. Colby [23] affirmed at the beginning of the nineties that the conceptions of what is the economy, what is technologically practical, what is ecologically necessary and what is politically feasible are changing rapidly.

Based on the experience of the authors and the growth of this type of research in fields related to environmental management, a set of recommendations has been generated that should be considered in order to reduce potential bias and other possible sources of error. It is recommended that any study that spans multiple disciplines refrain from using search filters that limit results to specific disciplines or areas. It is also advisable to use specific keywords using more sophisticated data collection strategies. Finally, any study that uses citation databases such as Scopus or WoS must implement, and report, a strategy for data cleaning of the references found. Although these databases present very attractive sources of information, due to inaccuracies in the citations of publications or internal problems of the database, they also often contain errors.

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