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Two Decades of Environmental Accounting: A Bibliometric Analysis

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Abstract: *This article aims to empirically examine research related to environmental accounting (EA) using bibliometric analysis over the span of two decades. As part of the methodology, the study applies bibliometric measures based on the analysis made through Biblioshiny from the Web of Science (WoS) database from 2000 to 2021. The bibliometric analysis found that EA has evolved as a rising discipline, although it still faces several challenges in being recognised in accounting and management research. The number of articles is growing, but a significant number of these papers were published in non-accounting journals. The limited number of articles and citations suggests that EA is still a developing field. The study has a few limitations, most of which are related to the use of bibliometrics. It only considers articles published in international journals through WoS databases and not conference proceedings. This might exclude a large amount of the current literature and other related research contributions to the field of EA. Business firms can engage in EA to gain competitive advantage and market value by marketising EA as part of their corporate social responsibility to increase value among stakeholders.*

Keywords: Environmental; Accounting; Bibliometric analysis; Biblioshiny; Web of Science.
JEL Classification: M41, Q56, E01

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1. Introduction

Environmental accounting (EA) is a branch of accounting that incorporates both environmental and economic data. EA can be performed either at the level of the firm, national economy or international economy. EA helps a firm track the effects of eco-friendly operations across the spectrum, from supply chains to facilitating growth. It enables directors to disclose compliance with environmental regulations in the firm's financial statements, thereby allowing stakeholders to make financial decisions.

Managers' understanding of environmental concerns has grown in recent decades. These concerns include global warming, greenhouse gas emissions, waste disposal, landfill site usage, land, and environmental pollution, energy consumption, and recycling of materials (Scarpellini et al., 2020). EA is believed to be a broad field of accounting that encompasses a wide range of topics. Environmental management accounting generates financial reports for internal managerial use, such as to assist management decisions on pricing a product, controlling fixed cost, financial budgeting. It is also used for external purposes, such as to disclose environmental information to stakeholders and for financial sectors. EA comprises the collection, analysis, and deployment of economic data in the context of a company's environmental and economic performance (Rounaghi, 2019). Generally, environmental, and social accounting are considered independent from financial accounting. Consider starting over in a world without a proper accounting system, a new strategy would almost certainly start with a much more holistic perspective (Nicholls, 2020).

Even though EA is becoming more important, it is still beset by certain difficulties. The disclosure requirements of EA information are still a hot topic. The lack of clear definitions of EA and weak regulations provide constraints on disclosure requirements and induce justifiable approaches to the environmental information disclosed in financial statements. A distinct judgment on environmental liability and environmental expenditure disclosures are deemed important (Senn & Giordano-Spring, 2020). Information technology-enabled EA systems face numerous challenges in the real world, such from the process of initiation to structuring through the allocation of information technology (IT) resources (Thottoli, 2022). The most difficult aspect of EA information systems is obtaining reliable measurements, which is one of the several difficulties that management

faces (Meiryani et al., 2019). Companies should study recent environmental protection and related regulations thoroughly and build up a unique EA information disclosure system. These companies should first decide on environment-related disclosure items, followed by gathering, classifying, and recording those items as part of regulatory disclosures (Liu & Liu, 2021). As Mahmood et al. (2018) urge, before setting any economic growth targets, Asian countries need to think about environmental implications. The environmental consequences of growth must be considered in context, as they may have far-reaching implications for the region and neighbouring countries. Further, regional foreign direct investment (FDI) and trade liberalisation has had a negative impact on the environment.

Mata et al. (2018) study EA using content analysis, which they believe is the most widely used approach. Buonocore et al. (2020) believe that most of the EA-related research uses a long-term perspective and employs content analysis as part of their methodology. An interdisciplinary method to assess natural capital and ecological services in maritime ecosystems can also be used. Literature reviews that include to many papers (Asmussen & Møller, 2019) and a bibliometric analysis used to visual maps and tables (Cui et al., 2018) can provide methodological contributions to the existing literature. Thus, the aim of this article is to empirically examine research related to EA using bibliometric analysis focused over the span of two decades.

This paper is organised as follows: Section 2 discusses the available literature. Section 3 explains the research method. Section 4 includes descriptive statistical results in addition to the bibliometric analysis. This bibliometric analysis is backed by bibliometric measures (Garfield, 1955; Bradford, 1985; De Bellis, 2009). Section 5 includes results and discussions. Section 6 consists of conclusions. Implications and limitations are discussed in Section 7.

2. Relevant Literature

Identifying study areas within a range of literature is critical for comprehending historical, current trends, and potential research areas in the future (Small et al., 2014). Chung and Cho (2018) focus on understanding related disciplines, such as current trends in EA, the definition of EA, theoretical perspectives, research methodologies, and research recommendations for further research. Marrone et al. (2020) use machine

learning to review the literature to identify the emergence of EA and future research trends. Further, they also trace the emergence of recent research trends over time. Skaf et al. (2019) employ a multicriteria accounting system to explore the EA performance and production of organic goods in the country on a national level. In the context of de-carbonisation targets, Fogarassy et al. (2018) underline the importance of EA on companies' financial performance, as well as the degree of its adoption in cement sectors. The most major changes in social and EA in emerging countries were evaluated by Qian et al. (2021) with the goal of providing insight into current research on the topic. The connection between the environmental expenditure and publicly traded oil and gas corporations' net profit is investigated by Nkwoji (2021). Nkundabanyanga et al. (2021) report on the relationship between board performance, EA, company attributes, and environmental performance disclosure among manufacturing companies.

The dearth of accounting means to detect, assess and disclose EA matters has driven a blend of environmental management accounting to help in fair financial statement reporting systems. Accordingly, Kassim et al. (2021) assess the institutional compliance regulatory pressures influencing environmental management accounting implementation by regional governments. Rodrigues et al. (2021) conduct a literature review study on social accounting regulatory disclosure to answer questions on research streams followed, research paradigms used, theories, as well as the inclusion of articles on the Web of Science (WoS) search database.

The effect of five distinct aspects on the implementation of EA in mining industries – corporate features, pressures of stakeholders, regulatory pressure of the government, awareness of environmental responsibilities among senior-level managers, and additional skills and education of an accountant with regards to EA – are discussed by Nguyen (2020). The study found that the pressure of stakeholders had an insignificant effect on the implementation of EA in mining industries, unlike the other four factors. Fusco and Ricci (2019) believe that social and environmental reporting research in the public sector is still in its inception.

Research on EA is gradually growing. Most publications are related to the areas to investigate what, why, and how listed companies disclose, though there might be some other aspects that should be examined extensively and require additional support for further research. Tahajuddin et al. (2021) find that society and media boost EA disclosure requirements

among small and medium enterprises (SMEs), allowing them to improve their environmental, inventory, and cost-controlling performance, as well as develop more efficient, low-polluting techniques and promote non-polluting products. Wichianrak et al., (2022) find that voluntary reporting is becoming more prevalent, with emissions data disclosure requirements. Only companies in the agriculture and food sectors were found to have a substantial impact on the number of disclosures made under Thailand's sustainability reporting rules, which were announced in 2012. They also found that environmental disclosures are significantly influenced by the firm's age and media attention. Profitability, on the other hand, was found to have a negative correlation with the degree of environmental regulatory disclosures.

3. Research Method

3.1 Database and selection of journals

Articles published in peer-reviewed journals can provide verified information, and bibliometric analysis can help to improve reliability (Ramos-Rodrigues & Ruis-Navarro, 2004). For a long time, WoS was the only tool available for citation analysis. While Scopus and Google Scholar databases are new to the market, they are useful additions to WoS. In some circumstances, it is possible to gain a more nuanced understanding of the value of scholarly articles in the social sciences (Levine-Clark & Gil, 2009). WoS database comprises more than 12,000 influential and high-impact scholarly journals from the Social Sciences Citation Index (SSCI) and Science Citation Index Expanded (SCIE) (Gong et al., 2019). Given its widespread recognition and academic significance, the current study relies on the WoS database. Scientific papers published in environmental, economics, ecology, green sustainable science technology, business, and management-oriented academic journals were analysed.

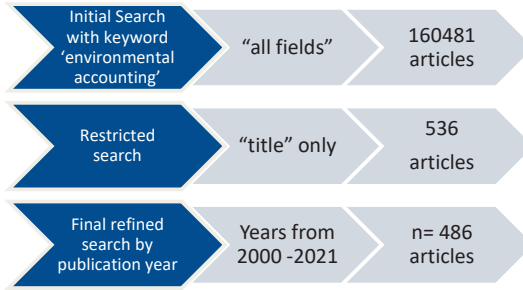
To arrange and study the research in EA, a bibliometric analysis was chosen as a part of the analysis. The collection of data and bibliometric analysis used to be undertaken manually (Garfield, 1955). Data synthesis has been much easier since the introduction of several approaches such as scientometrics and bibliometrics (Pritchard, 1969). Bibliometrics helped to track the 20 most relevant journals for this study, namely the *Journal*

of Cleaner Production, Ecological Economics, Ecological Modeling, Sustainability, Journal of Environmental Management, Accounting Auditing & Accountability Journal, Environmental Science and Pollution Research, Critical Perspectives on Accounting, Ecological Indicators, Environmental and Resource Economics, Science of the Total Environment, Sustainability Accounting Management and Policy Journal, Business Strategy and the Environment, International Journal of Life Cycle Assessment, Environmental Science and Technology, Journal of Business Ethics, Accounting Forum, Energy Policy, Environmental Impact Assessment Review, and *Journal of Industrial Ecology*.

3.2 Collection of data

To begin, the researchers conducted a literature review that can be extended to many papers. This was followed by a bibliometric analysis to add visual maps and tables that can be used to monitor the evolution of study topics in accounting and non-accounting reputed journals. The content of the search is TS = (environmental) AND (accounting). There are basically several Boolean operators including the operator AND, NOT, and OR (Kreimeyer et al., 2009). In the current research, the keyword analysis utilises a Boolean search that included the terms 'environmental' AND 'accounting' in all fields. The keywords were concatenated using Boolean operators ("AND" and "OR") and the * wildcard to construct query strings that initially returned 16,0481 hits across WoS databases since 1989. To further confirm the importance of the documents, the researchers search the keywords "environmental" AND "accounting" only in the 'title' of the papers published in the WoS database. The search resulted in 536 articles from the year 1989. The search was later refined by restricting publication years from 2000 to 2021. A total of (n) 486 usable articles were chosen for the study. The data gathering processes are shown in Figure 1 below.

Figure 1: Data Collection



3.3 Analysis

For bibliometric data analysis, the study considered articles, journal titles, year of publication, author name or type of information, represented institution, and article content. The articles that were chosen for analysis were published between 2000 to 2021.

4. Descriptive Analysis

This section explains relevant information on data, document types, document contents, authors, and author collaborations (see Table 1). There are 257 sources such as journals, books, etc. There are a total of 486 documents, with the average year from publications at 7.31, average citations per document 23.38, average citations per year per document 3.214, and 21,485 total references. The document type includes 398 articles, 7 early access articles, 16 proceeding papers, eight book reviews, two corrections, 22 editorial material documents, one editorial material early access document, one letter, eight meeting abstracts, one news item, 21 reviews, and one review early access document. The document contents consist of keywords plus (ID) 1,332, author's keywords (DE) 1,722, authors 1,331, author appearances 1,475, authors of single-authored documents 92, and authors of multi-authored documents 1,239. The are 100 single-authored documents, 0.365 documents per author, 2.74 authors per document, 3.03 co-authors per document, and a collaboration index of 3.21.

Table 1: Main Information

Description	Results
Main information about data	
Timespan	2000: 2021
Sources (journals, books, etc)	257
Documents	486
Average years of publication	7.31
Average citations per document	23.38
Average citations per year per document	3.214
References	21485
Document types (*n* =486)	
Article	398 (82%)
Article; early access	7(1.4%)
Article; proceedings paper	16(3.3%)
Book review	8(1.6%)
Correction	2(0.4%)
Editorial material	22(4.6%)
Editorial material; early access	1(0.2%)
Letter	1(0.2%)
Meeting abstract	8(1.6%)
News item	1(0.2%)
Review	21(4.3%)
Review; early access	1(0.2%)
Document contents	
Keywords plus (ID)	1332
Author's keywords (DE)	1722
Authors	
Authors	1331
Author appearances	1475
Authors of single-authored documents	92
Authors of multi-authored documents	1239
Author collaborations	
Single-authored documents	100
Documents per author	0.365
Authors per document	2.74
Co-authors per document	3.03
Collaboration index	3.21

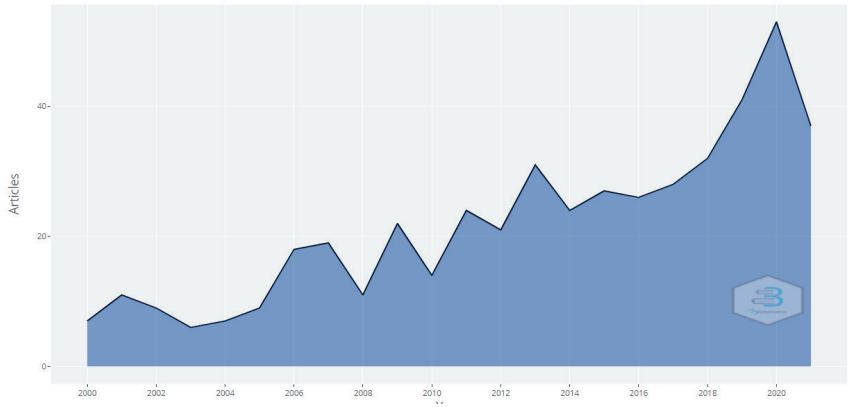
Source: Author's own.

5. Results and Discussion

5.1 Annual scientific production

The field of EA shows a growing trend of annual scientific production of documents (including articles, early access, proceedings paper, book review, etc.) in the last two decades, that is from 2000 to 2021. Annual scientific production is depicted in Figure 2. From 2000 to 2010, the total number of annual productions was kept to a minimum of 20. From 2011 onwards, the average number of annual productions showed an increasing trend which was above 20. The highest number of annual productions was 53 in the year 2020. According to the findings, the EA discipline has seen an uptick in the number of publications. The six authors who contributed the most articles are Buonocore 7, Franzese 5, Almeida 4, Alola 4, Burritt 4, and Vardon 4.

Figure 2: Annual Scientific Production

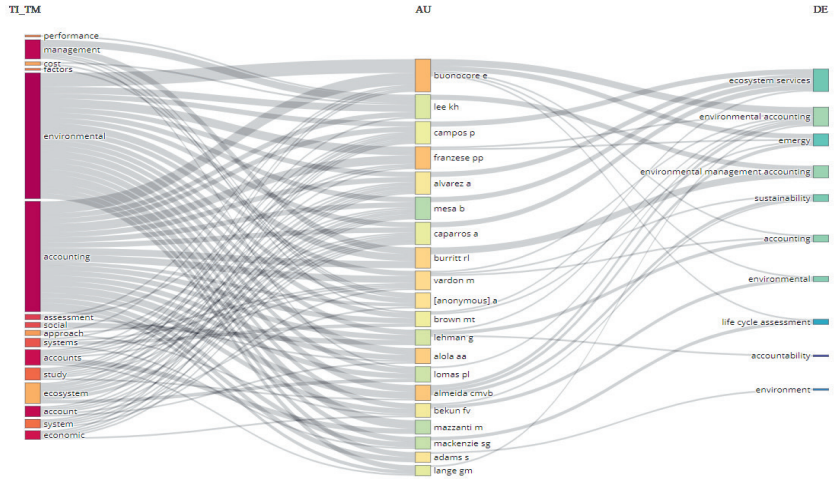


Source: Author's own.

5.2 Three-fields plot

Three factors are presented in the three-field plot (Figure 3), with titles, authors, and keywords used. The fields used in this analysis reveal their relationship with one another, starting with the title of the journal, then the authors of the journal, and the 'environmental accounting' keyword chosen by authors for their publications.

Figure 3: Three-fields Plot (author, titles, keywords)



Source: Author's own.

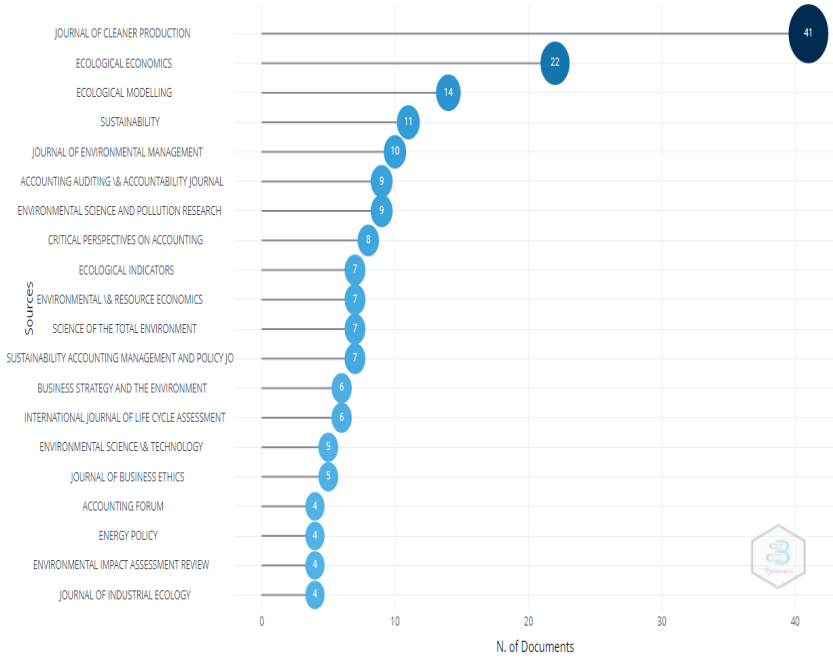
The left field involves journal titles. The 'environmental' incoming flow count is zero and the outgoing flow count is 20 for the title 'environment'. Whereas the 'accounting' incoming flow is zero and outgoing flow count is 19. The middle field involves details of the authors. There are 19 authors indexed in the three-fields plot who published papers related to EA. Among them, Buonocore shows the highest percentage with other authors, which is portrayed in a light orange colour rectangle and is connected by numerous keywords, including EA, ecosystem services, energy, environmental management accounting, and so on. The right field of the three-field plot consists of keywords, such as environmental accounting, ecosystem services, environmental management accounting, sustainability, and accounting, which are more frequently connected with varied authors.

5.3 Most relevant journals

Figure 4 depicts the 20 most relevant journals published in the field of EA. It reveals that the *Journal of Cleaner Production* had 20 articles, *Ecological Economics* 12; *Ecological Modeling* 11; *Accounting Auditing and Accountability Journal* 7; *Critical Perspectives on Accounting* 7; *Science of*

the Total Environment 6; *Sustainability Accounting Management and Policy Journal* 6; *Business Strategy and the Environment* five; *Environmental and Resource Economics* 5; *Environmental Science and Pollution Research* 5; *Journal of Business Ethics* 5; *Journal of Environmental Management* 5; *Accounting Forum* 4; *Ecological Indicators* 4; *Energy Policy* 4; *Environmental Science and Technology* 4; *International Journal of Life Cycle Assessment* 4; *Sustainability* 4; *Accounting Organisations and Society* 3; and *Environmental Impact Assessment Review* 3.

Figure 4: Most Relevant Journals



Source: Author's own.

5.4 Most journals on environmental accounting

Another form of bibliometric analysis, Bradford's law, can be used to make an intriguing observation. Bradford (1985) identified a pattern that anticipates the frequency of articles published in the core, affiliated, and

sporadic publications. Bradford proposed that the total number of published articles in key journals – the journals with the most publications on a particular topic – is equal to the same number of publications over the next linked journals. In the 486 studies selected by the present research, the first 98 publications are concentrated in five journals – *Journal of Cleaner Production*, *Ecological Economics*, *Ecological Modeling*, *Sustainability*, and *Journal of Environmental Management* (Table 2). The next 92 published articles are seen in the remaining 19 journals, while the remaining 296 articles are dispersed among 237 (barely related) journals. In comparison to the total number of key journals, overall figures show a significant under-representation in connected and marginally related publications. Although the multidisciplinary field of EA might have predicted an over-representation of related journals, the proportion of publications implies that the key area is much more strongly represented and performs an active role than the entire research area and other scientific fields in general.

Table 2: Journals on Environmental Accounting (*Bradford Law*)

Source	Rank	Freq	cumFreq
Journal of Cleaner Production	1	41	41
Ecological Economics	2	22	63
Ecological Modelling	3	14	77
Sustainability	4	11	88
Journal of Environmental Management	5	10	98
Accounting Auditing and Accountability Journal	6	9	107
Environmental Science and Pollution Research	7	9	116
Critical Perspectives on Accounting	8	8	124
Ecological Indicators	9	7	131
Environmental and Resource Economics	10	7	138
Science of the Total Environment	11	7	145
Sustainability Accounting Management and Policy Journal	12	7	152
Business Strategy and The Environment	13	6	158
International Journal of Life Cycle Assessment	14	6	164
Environmental Science and Technology	15	5	169
Journal of Business Ethics	16	5	174
Accounting Forum	17	4	178
Energy Policy	18	4	182
Environmental Impact Assessment Review	19	4	186
Journal of Industrial Ecology	20	4	190

Source: Author's own.

5.5 Author local impact by h-index

This section addresses the most outstanding authors' impact by the h-index in the field of EA. The table's structure is based on a portion of the first 20 relevant authors who published the highest number of articles. Table 3 distinguishes the most relevant authors and the number of publications, the related h-index, g-index, m-index, total citation, and start year in the top 20. In Table 2, it is evident that in the preferred sample, the author with the maximum h-index is Buonocore, having a h-index of 6. The top five are, namely, Almeida, Alola, Burritt, Franzese, and Vardon with a h-index of 4. The authors Brown, Lehman, Lomas, Mazzanti, Montini, Tilley, and Usman have a h-index of 3, and the remaining authors, Adedoyin, Agboola, Agostinho, Ahlgren, Appolloni, Barrella, and Bastianoni having a h-index of 2.

Table 3: Authors in Environmental Accounting (Top 20 Contributors)

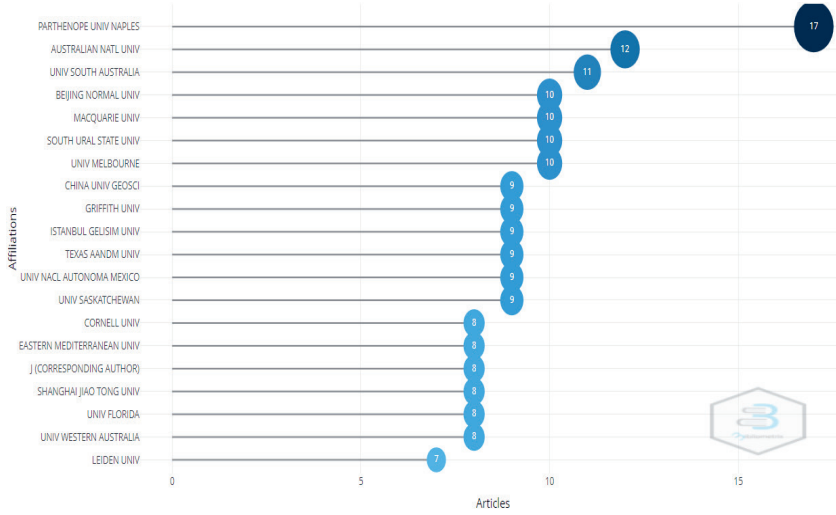
Author	No. of publications	h_index	g_index	m_index	Total citation	PY_start
Buonocore E	7	6	7	0.75	157	2014
Almeida CMVB	4	4	4	0.25	165	2006
Alola AA	4	4	4	1.333	158	2019
Burritt RL	4	4	4	0.25	271	2006
Franzese PP	5	4	5	0.5	77	2014
Vardon M	4	4	4	0.5	84	2014
Brown MT	3	3	3	0.188	86	2006
Lehman G	3	3	3	0.6	34	2017
Lomas PL	3	3	3	0.214	63	2008
Mazzanti M	3	3	3	0.2	64	2007
Montini A	3	3	3	0.2	64	2007
Tilley DR	3	3	3	0.188	103	2006
Usman O	3	3	3	1.5	104	2020
Adedoyin FF	2	2	2	2	18	2021
Agboola MO	2	2	2	2	12	2021
Agostinho F	2	2	2	0.222	44	2013
Ahlgren EO	2	2	2	0.167	38	2010
Appolloni L	2	2	2	1	25	2020
Barrella FA	2	2	2	0.125	130	2006
Bastianoni S	2	2	2	0.091	94	2000

Source: Author's own.

5.6 Most relevant affiliations

EA research has been carried out by several entities and affiliations all over the globe. The top twenty highest productive affiliations are represented in Figure 5. In general, the Parthenope University of Naples affiliation (top 17 affiliations) has the highest number of contributors with respect to EA research.

Figure 5: Most Relevant Affiliations



Source: Author's own.

5.7 Corresponding authors' country

Table 4 lists the top 20 countries that published the most articles on EA between 2000 to 2021. From the selected years, 53 countries contributed to the field of EA research. In recent years, bibliometric indices such as TP, CP, IP, RP, and FP have been used to assess a country's research performance (Ivanović & Ho, 2016). The United States (US) is placed first in TP (n 82), SCP (n 70), and MCP (n 12). Australia is the second most productive country in the case of total articles (n 50), SCP (n 34), and MCP (n 16). China emerged as third in the case of internationally collaborative articles (n 40), SCP (n 29), and MCP (n 11). For the remaining countries, rank and (TP)

were: United Kingdom (UK) 4 (35), Italy 5 (29), Spain 6 (24), France 7 (18), Germany 8 (17), Canada 9 (16), Sweden, 10 (12), Brazil 11 (11), Romania 12 (11), Netherlands 13 (10), Greece 14 (9), Turkey 15 (9), Austria 16 (6), Japan 17 (6), Norway 18 (6), Switzerland 19 (6), and Denmark 20 (5). These findings imply that developed nations are heavily invested in EA research. This could be related to the fact that developed countries have more funds available for research than developing countries.

Table 4: Traits of the 20 Contributing Nations

Country	Rank (TP)	Freq	SCP	MCP	MCP_Ratio
US	1 (82)	0.17672	70	12	0.1463
Australia	2 (50)	0.10776	34	16	0.3200
China	3 (40)	0.08621	29	11	0.2750
UK	4 (35)	0.07543	21	14	0.4000
Italy	5 (29)	0.0625	19	10	0.3448
Spain	6 (24)	0.05172	17	7	0.2917
France	7 (18)	0.03879	13	5	0.2778
Germany	8 (17)	0.03664	12	5	0.2941
Canada	9 (16)	0.03448	10	6	0.3750
Sweden	10 (12)	0.02586	10	2	0.1667
Brazil	11 (11)	0.02371	10	1	0.0909
Romania	12 (11)	0.02371	11	0	-
Netherlands	13 (10)	0.02155	5	5	0.5000
Greece	14 (9)	0.0194	7	2	0.2222
Turkey	15 (9)	0.0194	4	5	0.5556
Austria	16 (6)	0.01293	6	0	-
Japan	17 (6)	0.01293	4	2	0.3333
Norway	18 (6)	0.01293	3	3	0.5000
Switzerland	19 (6)	0.01293	3	3	0.5000
Denmark	20 (5)	0.01078	3	2	0.4000

Notes: TP: Total highly cited articles; SCP: Single-author highly cited articles; MCP: Multiple country publications

Source: Author's own.

5.8 Most locally cited documents

The most relevant papers in the board's distinctive community were identified using citation analysis. It has hitherto been proposed that citation analysis using bibliometric analysis enumerates the total number of times other articles cite a specific article to pinpoint the reputation and impact of that publication in a specific scientific research field (Kumar et al., 2020). According to WoS 'total number of times' citation count, the study examined the citation of the 486 selected studies (see Table 5). The twenty most cited papers are published by various journals. The two most cited articles were published in 2013 and 2003, respectively. The top article was written by Christ et al. (2013) with 16 local citations and 82 global citations, followed by Jasch (2003) with 15 local citations and 117 global citations. The top two articles were published in the same journal, namely the *Journal of Cleaner Production*.

Table 5: Most Locally Cited Documents

Authors	Year	Journal	Local citations	Global citations	LC/GC Ratio (%)	Normalised local citations	Normalised global citations
Christ KL, J Clean Prod	2013	Environmental Management Accounting (EMA): The Significance of Contingent Variables for Adoption	16	82	19.51	19.84	2.49
Jasch C, J Clean Prod	2003	The Use of EMA for Identifying Environmental Costs	15	117	12.82	5.63	3.86
Burritt Rl, J Clean Prod	2009	EMA for Cleaner Production: The Case of a Philippine Rice Mill	14	66	21.21	22	3.2
Burritt Rl, J Clean Prod	2006	EMA Applications and Eco-Efficiency: Case Studies from Japan	12	92	13.04	3.93	2.43
Gale R, J Clean Prod-A	2006	EMA as a Reflexive Modernization Strategy in Cleaner Production	10	50	20	3.27	1.32
Schaltegger S, J Clean Prod	2012	Tapping Environmental Accounting Potentials of Beer Brewing: Information Needs for Successful Cleaner Production	9	44	20.45	10.5	1.56

Authors	Year	Journal	Local citations	Global citations	LC/ GC Ratio (%)	Normalised local citations	Normalised global citations
Latan H, J Clean Prod	2018	Effects Of Environmental Strategy, Environmental Uncertainty and Top Management's Commitment on Corporate Environmental Performance: The Role of EMA	9	90	10	11.08	3.61
Qian W, J Clean Prod	2018	EMA and Its Effects on Carbon Management and Disclosure Quality	9	27	33.33	11.08	1.08
De Beer P,Ecol Econ	2006	Environmental Accounting: A Management Tool for Enhancing Corporate Environmental and Economic Performance	8	54	14.81	2.62	1.43
Franzese PP, Ecol Model	2014	Environmental Accounting: Energy, Systems Ecology, and Ecological Modelling	8	31	25.81	11.29	0.91
Mokhtar N, J Clean Prod	2016	Corporate Characteristics and EMA Implementation: Evidence from Malaysian Public Listed Companies (Plcs)	8	31	25.81	16	1.71
Burritt RL, J Clean Prod	2019	Diffusion of EMA for Cleaner Production: Evidence from Some Case Studies	8	31	25.81	20.5	2.74
Masanet-Llodra MJ, J Bus Ethics	2006	EMA: A Case Study Research on Innovative Strategy	6	37	16.22	1.96	0.98
Gale R, J Clean Prod	2006	Environmental Costs at a Canadian Paper Mill: A Case Study of EMA	6	36	16.67	1.96	0.95
Boyd J, Ecol Econ	2007	What Are Ecosystem Services? The Need for Standardized Environmental Accounting Units	6	1057	0.57	7.13	12.32

Authors	Year	Journal	Local citations	Global citations	LC/GC Ratio (%)	Normalised local citations	Normalised global citations
Vassallo P, Ecol Model	2017	Assessing The Value of Natural Capital in Marine Protected Areas: A Biophysical and Trophodynamic Environmental Accounting Model	6	47	12.77	16.8	2.3
Bouten L, Manage Account RES	2013	On the Interplay Between Environmental Reporting and Management Accounting Change	5	56	8.93	6.2	1.7
Sarkodie SA, Sci Total Environ	2018	Renewable Energy, Nuclear Energy, and Environmental Pollution: Accounting for Political Institutional Quality in South Africa	5	185	2.7	6.15	7.43
Staniskis JK, J Clean Prod	2006	EMA in Lithuania: Exploratory Study of Current Practices, Opportunities and Strategic Intents	4	35	11.43	1.31	0.93
Muller NZ, AM Econ Rev	2011	Environmental Accounting for Pollution in the US Economy	4	225	1.78	24	6.76

Source: Author's own.

5.9 Most frequent words

Frequently searched words are considered in the current study to gauge the popularity of the research topic, EA. This concerns the overall search conducted in this field (see Table 6). The most frequently searched words are performance (45), sustainability (43), management (37), impact (36), energy (20), model (20), systems (20), conservation (17), growth (17), CO2 emissions (15), framework (15), indicators (15), life-cycle assessment (15), accountability (14), climate-change (14), disclosure (14), emissions (13), services (13), efficiency (12), and information (12).

Table 6: Most Frequent Words

Words	Occurrences
Performance	45
Sustainability	43
Management	37
Impact	36
Energy	20
Model	20
Systems	20
Conservation	17
Growth	17
CO2 emissions	15
Framework	15
Indicators	15
Life-cycle assessment	15
Accountability	14
Climate-change	14
Disclosure	14
Emissions	13
Services	13
Efficiency	12
Information	12

Source: Author's own.

5.10 Tree-map

The tree-map (Figure 6) encapsulates the 20 most widely used keywords. Performance, sustainability, and management are the most frequently used by authors, followed by impact, energy, model, and systems. The connection between the performance and sustainability sector is quite evident from the tree map. Another field of EA that seems to be of importance to the researchers is CO2 emissions, pollution, water, energy consumption, eco-control, and governance. These author keywords are being used less frequently, probably because theoretical linkages are indeed developing in this field of study. Other keywords, such as environmental management accounting, consumptions, emissions, air pollution, carbon, and biodiversity, also show a lower frequency. This may be due to authors pointing to EA still

being in the development stage. These could also be viewed as potential research avenues in this domain.

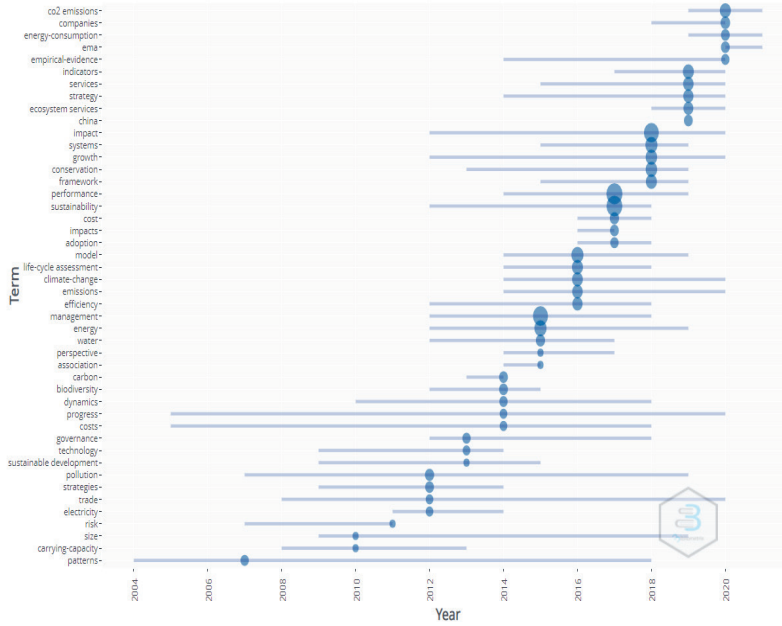
Figure 6: Tree-Map

Source: Author's own.

5.11 Trend topics

The bibliometric analysis of trend topics is depicted in Figure 7 below for the period 2014 to 2020. The topic and frequency of 46 items are: carbon dioxide (CO_2) emissions (15), companies (10), environmental management accounting or EMA (eight), energy consumption (eight), empirical evidence (seven), indicators (15), services (13), strategy (12), ecosystem services (11), China (8), impact (36), systems (20), conservation (17), growth (17), framework (15), performance (45), sustainability (43), cost (nine), impacts (eight), adoption (7), model (20), life-cycle assessment (15), climate change (14), emissions (13), efficiency (12), management (37), energy (20), water (nine), association (five), perspective (five), biodiversity (eight), carbon (eight), dynamics (seven), costs (six), progress (six), governance (seven), technology (six), sustainable development (five), pollution (9), strategies (eight), electricity (six), trade (six), risk (five), carrying-capacity (five), size (five), and patterns (seven). This analysis may help the researchers to comprehend the trending themes in the topic of EA.

Figure 7: Trend Topics

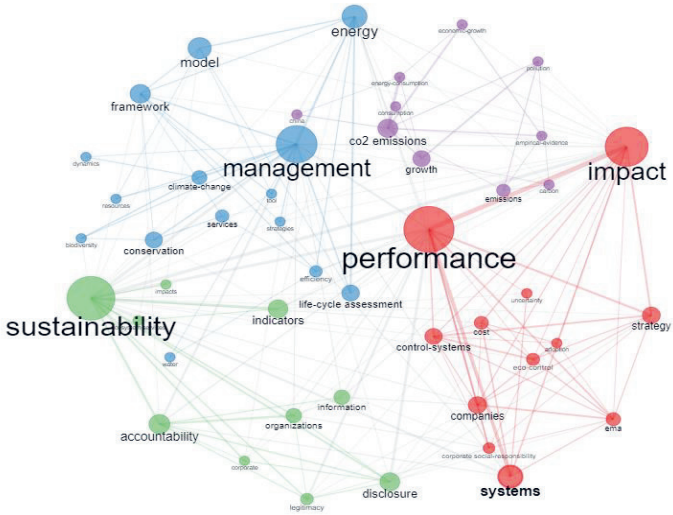


Source: Author's own.

5.12 Co-occurrence network

From 2000 to 2021, the words performance, sustainability, management, and impact were the core focus of co-occurrence networks. Consequently, co-occurrence networks concerned with the system, energy, model strategy, and accountability appeared in the latter part of the study. At present, EA has gained a new international emphasis. Figure 8 signifies the keyword of co-occurrence network between the years 2000 and 2021. The size of the node indicates the level of co-occurrence, which is the total number of times two keywords appear together.

Figure 8: Co-occurrence Network



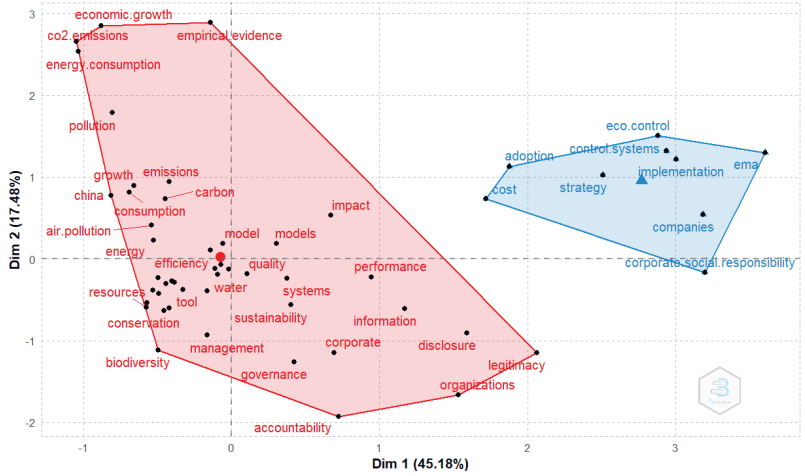
Source: Author's own.

5.13 Conceptual structure map, MCA method

Figure 9, a conceptual structure-map, categorises the two clusters (red and blue) of repeated keywords. The red cluster comprises the keywords such as economic growth, CO_2 emissions, energy consumption, pollution, growth emission, carbon, consumption, air pollution, and energy. Beginning from these repeated keywords, one can recognise that the central subject of this cluster could relate to the EA field. The blue cluster comprises keywords, such as eco control, control system, adoption, environmental management accounting, adoption, cost, companies, and corporate social responsibility.

The red cluster contains more keywords than the blue cluster, and they appear to be consistent with one another at first glance. As a result, we might assume that the red cluster reflects a more important topic than that the blue cluster.

Figure 9: Conceptual Structure Map, MCA Method

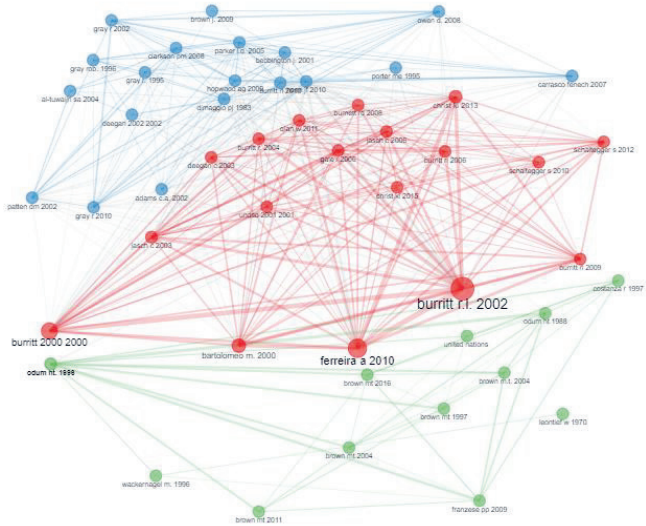


Source: Author's own.

5.14 Co-citation network

The examination of author co-citations provides various important insights into the authors' impact on the field of EA. The co-citation analysis for the field of EA is shown in Figure 10. The density of the arrows reflects the strength of co-citation relationships. The width of the squares shows the authors' co-citation frequency. The ties between authors demonstrate their proximity rather than their physical proximity. Based on the type of citation, network edges might have multiple interpretations, such as direct citation or co-citation. Citation analysis, which takes the form of co-citations between authors or publications, is the most prevalent bibliometrics analysis. When looked at over a period, co-citation analysis can reveal a shift in fundamental schools of thinking (Small, 1973). There are three thoroughly disturbed clusters seen in Figure 10. Sub clusters links are established in a variety of other themes, which are distinguished by the varied colours. The other cluster is outlined in blue. The first cluster in blue can be considered as the inverse of bibliographic coupling that can be observed above the centre of gravity. The analyses' central red theme is made up of individual studies on EA. The green cluster is particularly with other subjects of this co-citation network analysis.

Figure 10: Co-citation Network

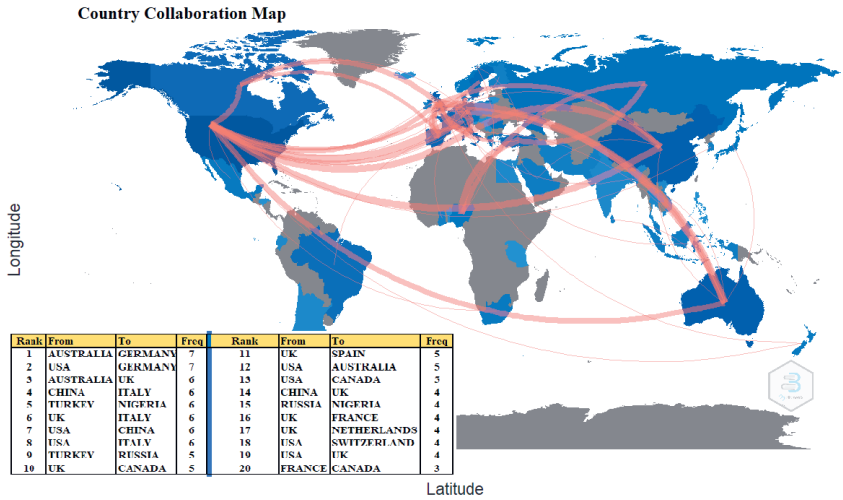


Source: Author's own.

5.15 Country collaboration map

Figure 11 shows the country collaboration map on EA literature. Australia and the US emerged as the top collaborator with seven publication each with Germany, followed by Australia with the UK, China with Italy, Turkey with Nigeria, the UK with Italy, the US with China, and the US with Italy (six publications each), Turkey with Russia, the UK with Canada, the UK with Spain, US with Australia and US with Canada (five publications each), China with the UK, the UK with France, the UK with the Netherlands, UK with Switzerland and US with UK (four publications each). Among the 20 collaborators, the countries that collaborated the least were France with Canada, with only one publication.

Figure 11: Country Collaboration Map



Rank	From	To	Freq
1	AUSTRALIA	GERMANY	7
2	USA	GERMANY	7
3	AUSTRALIA	UK	6
4	CHINA	ITALY	6
5	TURKEY	NIGERIA	6
6	UK	ITALY	6
7	USA	CHINA	6
8	USA	ITALY	6
9	TURKEY	RUSSIA	5
10	UK	CANADA	5

Rank	From	To	Freq
11	UK	SPAIN	5
12	USA	AUSTRALIA	5
13	USA	CANADA	5
14	CHINA	UK	4
15	RUSSIA	NIGERIA	4
16	UK	FRANCE	4
17	UK	NETHERLANDS	4
18	USA	SWITZERLAND	4
19	USA	UK	4
20	FRANCE	CANADA	3

Source: Author's own.

6. Conclusions

EA is a branch of accounting that aims to integrate both environmental and economic costs with relevant disclosures in the financial statements of any company. As per the notion of economic social accounting, there are not just two users (creditors and stockholders) of financial statements in any business organisation; many other groups, like the wider society, benefit from business operations. As a result, the goal of increasing shareholder stake is to the benefit of the environment and society, while also increasing social accountability (Sayyadi et al., 2020). When firms establish sound EA practices, it can assist businesses in understanding and managing the possibility of a trade-off between conventional accounting goals and current environmental goals. It also enhances the essential information accessible for examining policy matters, particularly when those crucial pieces of information are frequently overlooked. EA is thought to protect weak sustainability, which would be considered a step toward achieving greater sustainability in the long run.

The bibliometric analysis found that EA has evolved as a discipline, although it still faces several challenges in being recognised in the accounting and management research fields. The number of articles is growing, but a significant portion of the papers are published in non-accounting journals. The limited number of articles and citations suggest that EA is still a developing field of research.

The research findings of the current study comprise varied analyses using bibliometric R software, such as annual scientific production, three-field plot, most relevant sources, most journals on EA (Bradford's law), author local impact by h-index, most relevant affiliations, corresponding authors' countries, most local cited documents, most frequent words, tree-map, trend topics, co-occurrence network, conceptual structure map, co-citation network, and country collaboration map between 2000 and 2021, which help to recapitulate key research findings. The most significant research contributions were identified, along with the trending research fields, nationwide collaborative research, and organisational collaborations.

Keywords such as environmental management accounting, consumption, emissions, air pollution, carbon, and biodiversity show a low frequency. This might signify that the authors are trying to state that the provision of EA is still in the development stage. These could also be viewed as potential research avenues in this domain. It will also help scholars and others identify potential research gaps in EA and address them. The findings also reveal that the number of EA research articles with an emphasis on broad topics – for instance, corporate social responsibility and stakeholder theory – has increased significantly (Marrone et al., 2020).

7. Implications and Limitations

The findings of this research have both theoretical and practical implications. In terms of theoretical contribution, it adds to the current literature by providing valuable insights into the topic of EA. This bibliometric analysis, particularly, could catalyse scholars interested in exploring this research issue in a variety of ways.

First, a collection of the 20 most cited publications and their contents are provided, underlining the cornerstone articles from which to begin analysing the topic. The study used bibliometric analysis to show what topics were previously established, and how. As a result, the study suggests the trending

areas of research that lack extensive research.

Additionally, the study examined the results of annual scientific production, three-field plot, most relevant sources, most journals on EA, author local impact by h-index, most relevant affiliations, corresponding authors' countries, most local cited documents, most frequent words, tree-map, trend topics, co-occurrence network, conceptual structure map, co-citation network, and country collaboration map to provide recommendations of journals that might be chosen for future research publication, and manifest their broad approaches on the related research topic. This research will assist policymakers and journal editors in determining which areas require more targeted efforts to promote EA practices among industries. This study also enhances government policymakers, particularly concerning non-performing environmental laws.

In terms of practical implications, the current study identified the importance of EA and its emergent trending topics and further research fields. It also underlines the implications for company directors to emphasise proper accounting for environmental regulatory issues to achieve organisational success and create a sustainable brand image among stakeholders. In this context, management can identify environmental requirements (voluntary or mandatory) to rethink and enhance their accounting processes to maintain brand image and ensure fair financial statement presentation through proper environmental disclosures.

The major limitation of the current study is that the bibliometric analysis was restricted only to the WoS database, even though WoS contains the most influential texts in any literature (Kessler, 1963). This might exclude a large amount of current literature on EA and other related research contributions. Other databases such as Scopus might be used in future research.

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