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Trends in research on climate change and organizations: a bibliometric analysis (1999–2021)

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Abstract

The effects of climate change are a source of uncertainty for businesses worldwide. Climate change has been causing significant and disruptive changes in the socio-ecological systems in which organizations interact. This study aims to provide a holistic assessment of the intersection of climate change and organizational literature since the end of the twentieth century. It seeks answers to the following questions: What is the evolution of this subject during 1999–2021? What are the leading research organizations and main journals contributing to this subject? Who are the main authors? What thematic clusters are found in the literature? Which theme has not been sufficiently researched and requires further attention? We analyzed 1476 publications obtained from the Web of Science database using two bibliometric methods: co-citation and co-word network analysis. The analysis showed that the University of Queensland, Australia, is the most productive research organization, and *Energy Policy* is the most productive journal. Ans Kolk and Michael E. Porter are the most cited authors in the literature. The cluster analysis identified five main themes: corporate environmental strategies and policies, corporate environmental outcomes and reporting, corporate environmental pressures, corporate governance and environmental management, and environmental finance.

Keywords Climate change · Organizational research · Bibliometrics · Social network analysis · Sustainability

JEL Classification M10 · M14 · M21 · O50 · Q54 · Q56 · Q57

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1 Introduction

Climate change is a source of uncertainty for businesses (Heal and Kriström 2002). It is a massive discontinuous change that causes changes in the global average temperature, disturbance in precipitation patterns, and occurrence of extreme weather events (Adelekan et al. 2022; Busch 2011; Linnenluecke et al. 2013). The inability to cope with such environmental impacts has left firms vulnerable to failure and losses (Busch 2011; O'Brien and Sygna 2013). Particularly vulnerable are those sectors that rely on specific temperatures and seasonal conditions, such as agriculture, forestry, and tourism, or those having industrial facilities located in climate-sensitive areas, such as coastal areas and floodplains (Masson-Delmotte et al. 2019). As previous research describes, climate change has effects that differ from any other shocks that industries and firms usually face (e.g., technology change or competitive dynamics) (Sharma and Alberto Aragón-Correa 2005; Winn et al. 2011).

Climate change has both direct and indirect effects on firms. Direct impact refers to the impact of unfavorable natural conditions, such as soaring temperatures, greater variations in the amount and timing of rainfall and snowfall, sea level rise, and increase in the frequency and intensity of weather-related disasters (IPCC 2022), on the way in which firms and organizations conduct their business. Climate change has an indirect impact on businesses by producing changes in social norms (Park 2021). For example, financial regulators have begun implementing policies to address climate risks among banks, insurers, and other financial institutions (Kress 2022); courts have upheld citizens' fundamental right to protection from climate change by implementing changes in corporate criminal liability in the context of environmental, social, and governance (ESG) initiatives (Nelson 2022). Therefore, firms face both physical risks associated with the increased frequency and severity of extreme weather events and transition risks related to regulatory and policy changes caused by the shift to a sustainable economy (Bui and De Villiers 2017).

Organizations need to address the challenges of climate change to maintain their competitive advantage and survival. As organizations and industries constitute an essential part of our society, they play a central role in supporting societal responses to climate change (Berkhout 2012; Bhatt and Ghuman 2022; Frerichs and Teichert 2021; Guillén et al. 2021; Linnenluecke and Griffiths 2010; Pinkse and Gasbarro 2019; Velte 2021). To overcome the impacts of climate change, organizations can implement two types of strategies—*mitigation strategies* aimed to reduce greenhouse gases emissions (GHG) and *adaptation strategies* aimed to develop adjustments in managing and responding to actual or expected climate physical impacts and risks (Demski et al. 2017; Ingham et al. 2007; Kabisch et al. 2016). As climate change impacts are inevitable, some scholars have suggested that efforts should be made to design and implement adaptation strategies (Gasbarro and Pinkse 2016; Michailidou et al. 2016; Oliva et al. 2022; Reed et al. 2013).

Although research on the intersection of climate change and organizations has increased since the end of the twentieth century, there has not been any effort

to synthesize the extant research on this topic. Therefore, to close this gap, our study is motivated by the following overarching question: **How has research on climate change and organizations evolved and how could it move forward**? This study synthesizes the literature based on a four-stage systematic review employing bibliometric methods (i.e., co-citation and co-word network analysis). In doing so, we delved into the evolution of the subject by reviewing the leading research organizations, prominent journals, and main authors that have contributed to this topic during the period 1999–2021. Further, we developed a thematic cluster to shed light on themes that lack research and require further attention.

According to our results, scholarly interest in this topic has increased since 1999, achieving momentum in 2021. The University of Queensland, Australia, is the most productive research organization. The region with the highest publication density (i.e. number of papers published) is Europe. *Energy Policy* is the most productive journal, and Ans Kolk and Michael E. Porter are the most cited authors. In addition, the cluster analysis sheds light on the most frequently studied themes grouped into five clusters: corporate environmental strategies and policies, corporate environmental outcomes and reporting, corporate environmental pressures, corporate governance and environmental management, and environmental finance. The present study contributes to climate studies by identifying the major gaps to be closed in future research. It also contributes to the management and organizational literature by focusing on a major threat (i.e., climate change) to the survival of businesses. Additionally, our study contributes to one Sustainable Development Goal (SDG), as we propose further research to coordinate climate action (SDG no. 13) in the face of massive ecological discontinuous changes.

This paper is organized as follows. Section two presents the data and bibliometric methods used. Section three summarizes the results and discussion. Section four discusses implications and empirical gaps. Section five presents the conclusions of this study. Finally, we present the limitations and future research in Section six.

2 Data and methods

To answer our research questions, we followed the four-stage preferred reporting items for systematic reviews and meta-analyses (PRISMA) protocol. The protocol consists of four interrelated stages—identification, screening, eligibility, and inclusion—that provide a transparent process for reviewing the material (Hansen et al. 2021; Kuckertz and Block 2021; Lim et al. 2022; Rojas Molina et al. 2022). Figure 1 illustrates the procedure used for each stage.

The identification stage was based on six considerations: (i) source type, (ii) search engine, (iii) search category, (iv) search language, (v) search period, and (vi) search keywords. First, the systematic review only considered journal articles in terms of source type. Other types of publications (e.g., books, book chapters, industry reports, and conference proceedings) were not included, as they did not contribute to empirical or theoretical discussions. Second, in terms of the search engine, the Web of Science (WOS) database was selected because of the quality and availability of journal articles, as suggested by prior research (Du et al. 2021;

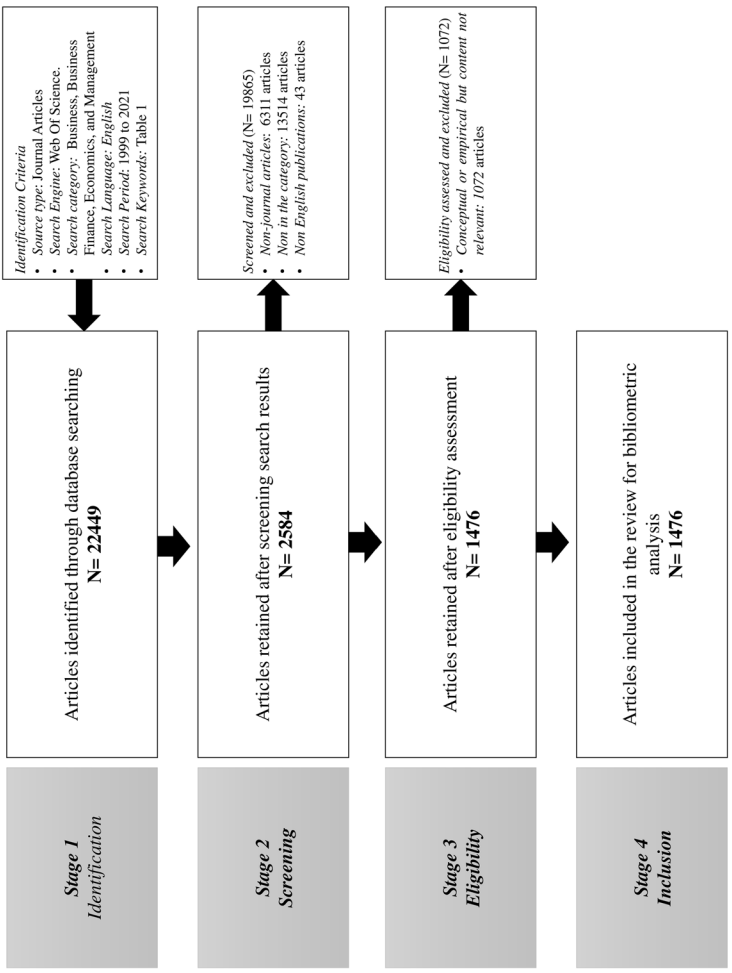


Fig. 1 Research protocol

Goyal et al. 2021; Li et al. 2021; Mallawaarachchi et al. 2020; Woldt et al. 2019; Ye et al. 2020; Zhang and Liang 2020).

Third, in terms of search categories, we focused on articles on the WOS categories of business, business finance, economics, and management because of our research objective. Fourth, we focused on English writing, as it is the primary language in WOS articles. Fifth, the search period was 1999–2021 to ensure all relevant articles were included in the analysis. Finally, in terms of search keywords, we employed a set of related keywords (see Table 1) used in previous studies to cover organizations (Alayo et al. 2021; Bužavaitė et al. 2019; Kücher and Feldbauer-Durstmüller 2019; López-Fernández et al. 2016; Parastuty 2018) and climate change (Aleixandre-Tudó et al. 2019; Santos and Bakhshoodeh 2021; Wang et al. 2018).

In total, 22,449 documents were retrieved after the identification stage. Therefore, the screening stage was continued. We omitted all publications that did not fit our identification criteria during the screening stage. In total, 19,865 documents were excluded from further analysis: 6311 were not journal articles; 13,514 were not related to the selected WOS categories; and 43 had a language different from English. The remaining 2548 publications entered the eligibility stage. The eligibility stage considered the content relevance of the articles as the primary exclusion criterion. The authors independently read the titles and abstracts of each publication to ensure that only those that focused on organizations and climate change were included. In total, 1072 articles were excluded because they did not meet the eligibility criteria. Next, came the inclusion stage.

A total of 1476 publications were included in the analysis. The remaining publications cover the 1999–2021 (December) period. The inclusion stage consisted of a validation check; a statistical analysis of the publications; and a bibliometric analysis assessing the networks of authors, sources, references, and keywords networks (Block and Fisch 2020; Lim et al. 2022). Initially, the authors independently validated the complete process to ensure the robustness of the previous three stages. Subsequently, we conducted an initial statistical analysis to identify the indicators of scientific production (e.g., the annual change in the number of publications and the distribution of scientific production by organizations, world regions, and journals).

We employed two bibliometric methods using co-citation and co-word network analysis. First, co-citation analysis is defined as the frequency with which two units (i.e., authors, documents, or journals) are cited together (Zupic and Čater 2015). It builds on the assumption that the more the two units are used jointly, the more likely it is that their content is related (McCain 1990, 1991; Small 1973). The output of co-citation analysis is a network of themes that represents the *intellectual space* of the field. Second, co-word analysis is a technique that uses words in documents (i.e., titles, abstracts, keywords, or full text) to construct a similarity measure within them. The underlying assumption is that when words frequently co-occur, the concepts behind them are closely related (Zupic and Čater 2015). The output of co-word analysis is a network of themes that represents the *conceptual space* of the field (Callon et al. 1983). This study builds on the *Author Keyword* technique (Block et al. 2020) for the development of co-word analysis. The information was processed using VosViewer (Version 1.6.17) because it allows the generation of co-occurrence

Table 1 Keywords used in the Web of Science query

Themes	Keywords	Author
Organization	("firm*") or ("business*") or ("corporate*") or ("company*") or ("enterprise*") or ("venture*") or ("organization*") or ("organisation*") or ("sme")	Alayo et al. (2021); Bužavaitė et al. (2019); Kücher and Feldbauer-Durstmüller (2019); López-Fernández et al. (2016); Parastuty (2018)
Climate change /Global warming/ Climate emergency	("*climat* chang*") or ("*climat* warming*") or ("*global temperature*") or ("global warm*") or ("*greenhouse gas*") or ("*greenhouse effect*") or ("greenhouse warm*") or ("anthropogenic warming*") or ("anthropogenic emission*") or ("climat* model*") or ("environment* chang*") or ("global chang*") or ("climat* variability and change") or ("carbon emission*")	(Aleixandre-Tudó et al. (2019); Santos and Bakhshoodeh (2021); Wang et al. (2018)

and co-word networks, and it is compatible with the WOS dataset (Van Eck and Waltman 2013).

3 Results and discussion

3.1 Basic characteristics of the literature

3.1.1 Annual change in the number of publications

As shown in Fig. 2, the number of publications showed an upward trend from 1999 to 2009, with an average of 12 per year. The publication trend increased significantly during 2010–2019, with approximately 87 articles published per year. We observed a publication peak in 2012 with 45% extra documents ($n=30$), in contrast with 2011. This could be explained by an increase in publication activity in journals such as *Business & Society* (194.6%), *Energy Economics* (179.2%), *Environmental Resource Economics* (69.3%), and *Business Strategy and the Environment* (40.5%). In addition, some journals (e.g., Organization Studies, Corporate Social Responsibility and Environmental Management, and Actual Problem of Economics) joined the conversation, increasing the number of articles. Since 2020, the yearly number of publications increased by an average of 38.5% in contrast to the highest peak in the 2010–2019 period, and reached 274 in 2021.

3.1.2 Distribution by world region and organizations

As illustrated in Fig. 3, the region with the largest number of publications was the United States ($n=369$; 17.63%), followed by England ($n=201$; 9.60%), Australia ($n=183$; 8.74%), and China ($n=153$; 7.31%). Figure 4 shows the publication density of regions around the world contributing to research on organizations and climate change. The analysis covered eight regions: North America, Central America, South America, Europe, Asia, Middle East, Africa, Australia, and Oceania. Europe had the highest publication density ($n=878$; 41.9%), followed by North America ($n=485$; 23.2%), Asia ($n=386$; 18.4%), and Australia and Oceania ($n=210$; 10.0%). Together, the four regions accounted for 93.6 percent of all research.

We observed scant research in Africa ($n=61$; 2.9%), the Middle East ($n=28$; 1.3%), South America ($n=45$; 2.2%), and Central America ($n=0$; 0%). The main contributing countries in each region were England (Europe), the United States of America (North America), China (Asia), Australia (Australia & Oceania), South Africa (Africa), the United Arab Emirates (Middle East), and Brazil (South America).

Based on the number of publications, University Queensland (Australia) made the most significant contribution to the literature during the 1999–2021 period with 20 articles. University Sydney (Australia), Macquarie University (Australia), and University Newcastle (United Kingdom) published 19, 18, and 15 articles, respectively, in the same period. The results suggest that no organization has a larger advantage in the field. As Table 2 suggests, universities from Australia, the United Kingdom,

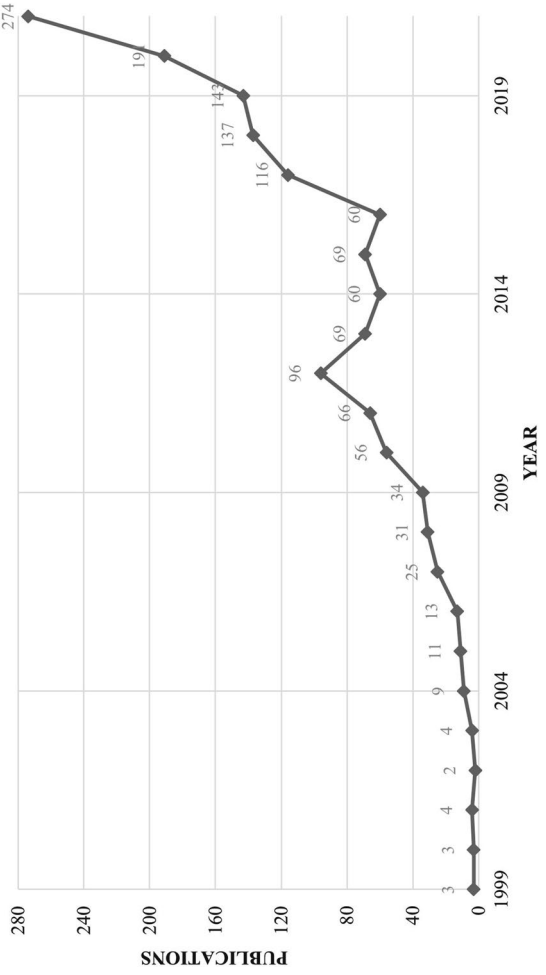


Fig. 2 Evolution in the number of articles

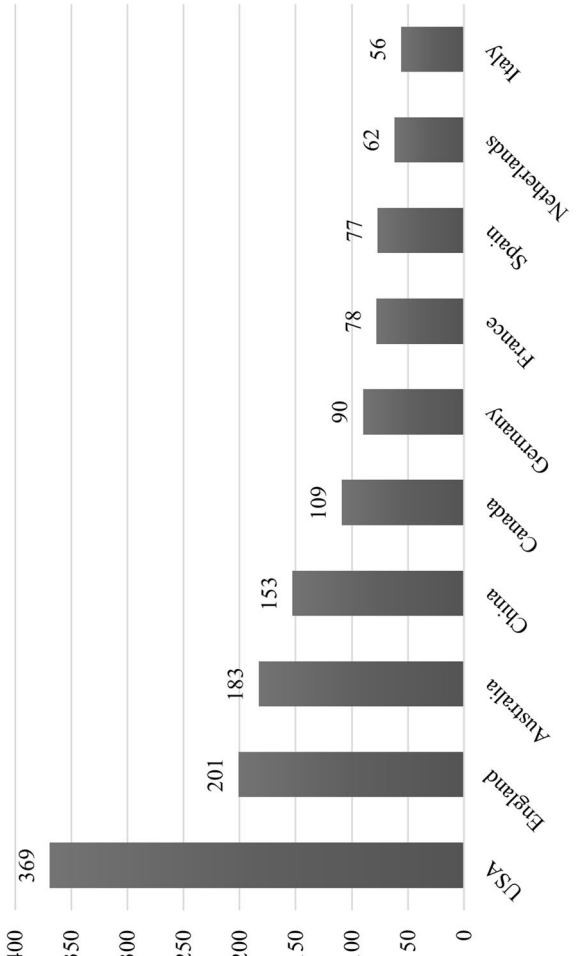


Fig. 3 Top 10 contributing regions

Fig. 4 Global distribution of publication density

Table 2 Top 10 organizations contributing to research on the subject of climate change and organizations

Organization	Region	Number of publications	Citations
University Queensland	Australia	20	1106
University Sydney	Australia	19	1171
Macquarie University	Australia	18	222
University Newcastle	United Kingdom	15	737
University Oxford	United Kingdom	15	654
University Leeds	United Kingdom	14	739
University Michigan	United States of America	13	581
Western Sydney University	Australia	13	81
University Edinburgh	United Kingdom	12	288
University Massachusetts	United States of America	12	614

and the United States of America have taken the lead in climate change and organizational research with 69, 56, and 25 studies, respectively, in the top 10. There were no universities from developing economies in the top 10 ranking.

3.1.3 Journal analysis

The largest number of articles were published in *Energy Policy* ($n=162$, citations = 5571), followed by *Business Strategy and the Environment* ($n=111$, total citations = 3163), and *Energy Economics* ($n=57$, total citations = 1452). As Table 3 summarizes, the journals with a higher five-year impact factor (IF) in this area were *Business Strategy and the Environment* (IF = 10.302), followed by *Corporate Social Responsibility and Environmental Management* (IF = 8.741), and *Technological Forecasting and Social Change* (IF = 8.593). Lastly, *Ecological Economics* had the highest number of citations per paper (52.33), followed by *The Journal of Business Ethics* and *Business and Society* with 49.72 and 46.50, respectively. Table 4 lists the top 10 journals by co-citations. Of those, *Business Strategy and the Environment* ($n=1544$), *Journal of Cleaner Production* ($n=1516$), and *Energy Policy* ($n=1506$) were cited more than 1500 times. *Business Strategy and the Environment* ranked in the first quartile of journal citation ranking, including the "business", "environmental sciences", and "management" categories.

We implemented a cluster detection analysis to observe the community-like structure within the journal's co-citation network. Based on this, we uncovered the intellectual communities within the field. Cluster detection analysis was performed using the weighted and parameterized variant of the modularity-based clustering technique integrated in the VosViewer software (Van Eck and Waltman 2013; Waltman et al. 2010).

The cluster analyses (Fig. 5) identified five clusters based on journal characteristics and topics. Cluster 1 (red) contains journals such as *Business Strategy and the Environment*; *Journal of Business Ethics*; and *Accounting, Organizations, & Society*. Cluster 2 (green) includes journals such as *Harvard Business Review*, *Business*

Table 3 Top 10 contributing journals

Journal	WOS category	IF	TP	TP%	TCT	CPP
Energy Policy	Economics; energy & fuels; environmental sciences; environmental studies	6.142	162	10.98	5571	34.39
Business Strategy and the Environment	Business; environmental studies; management	10.302	111	7.52	3163	28.50
Energy Economics	Economics	7.042	57	3.86	1452	25.47
Environmental & Resource Economics	Economics; environmental studies	2.181	35	2.37	397	11.34
Corporate Social Responsibility and Environmental Management	Business; environmental studies; management	8.741	34	2.30	1102	32.41
Ecological Economics	Ecology; economics; environmental sciences; environmental studies	5.389	33	2.24	1727	52.33
Journal of Business Ethics	Business; ethics	6.430	32	2.17	1591	49.72
Technological Forecasting and Social Change	Business; regional & urban planning	8.593	24	1.63	371	15.46
Business and Society	Business	7.389	18	1.22	837	46.50
Journal of Environmental Economics and Management	Business; economics; environmental studies	4.624	17	1.15	688	40.47

IF, impact factor, *TP*, total publications, *TP%*, percentage of TP over total, *TCT*, total citations, *CPP*, average citations per publication

Table 4 Top 10 journals by co-citation

Sources	Local citations	Links	Total link strength
Business strategy and the environment	1544	405	71,608
Journal of cleaner production	1516	410	60,025
Energy policy	1506	404	42,453
Journal business ethics	1266	399	59,660
Strategic management journal	1228	404	59,976
Academy of management review	1013	399	48,206
Academy of management journal	962	395	48,260
Ecological economics	722	408	26,918
Accounting, organizations and society	709	372	31,883
Energy economics	689	371	22,524

Local citations refer to citations within the 1476 publications used in this study. Links refer to the number of connections within the publications. The link strength identifies the strength of the total links with a positive value

and Society, and *Climatic Change*. Cluster 3 (blue) includes journals such as *The American Economics Review*, *The American Journal of Agricultural Economics*, and *Applied Economics*. Cluster 4 (yellow) includes journals such as *Academy of Management Annals*, *Academy of Management Journal*, and *Academy of Management Perspectives*. Lastly, Cluster 5 (purple) includes journals such as *The Journal of Cleaner Production, European Journal of Operational Research,* and *Management Sciences*.

3.2 Network analysis of authors

We implemented a cluster detection analysis to observe the community-like structure within the author's co-citation network. Based on this analysis, we identified the predominant intellectual groups within the field. Cluster detection analysis was performed using the weighted and parameterized variant of the modularity-based clustering technique integrated in the VosViewer software (Van Eck and Waltman 2013; Waltman et al. 2010).

The cluster analyses (Fig. 6 and Table 5) identified four clusters based on the authors' lines of inquiry. Cluster 1 (red), the business sustainability cluster, includes scholars such as Ans Kolk, Andrew Hoffman, and Pratima Bansal. Cluster 2 (green), the energy, environment, and technology cluster, includes researchers such as Michael Porter, Toshiyuki Sueyoshi, and multilateral institutions such as the European Commission. Cluster 3 (blue), the environmental and social disclosure and reporting cluster, contains scholars such as Peter Clarkson, Laura Luo, and Craig Deegan. Finally, Cluster 4 (yellow), the corporate sustainability strategies and performance cluster, includes authors such as Stuart Hart, Eugene Fama, and Timo Busch.

Table 6 shows the top 10 authors by co-citation, based on the total number of local citations. Kolk was co-cited more than 300 times ($n = 355$). She was

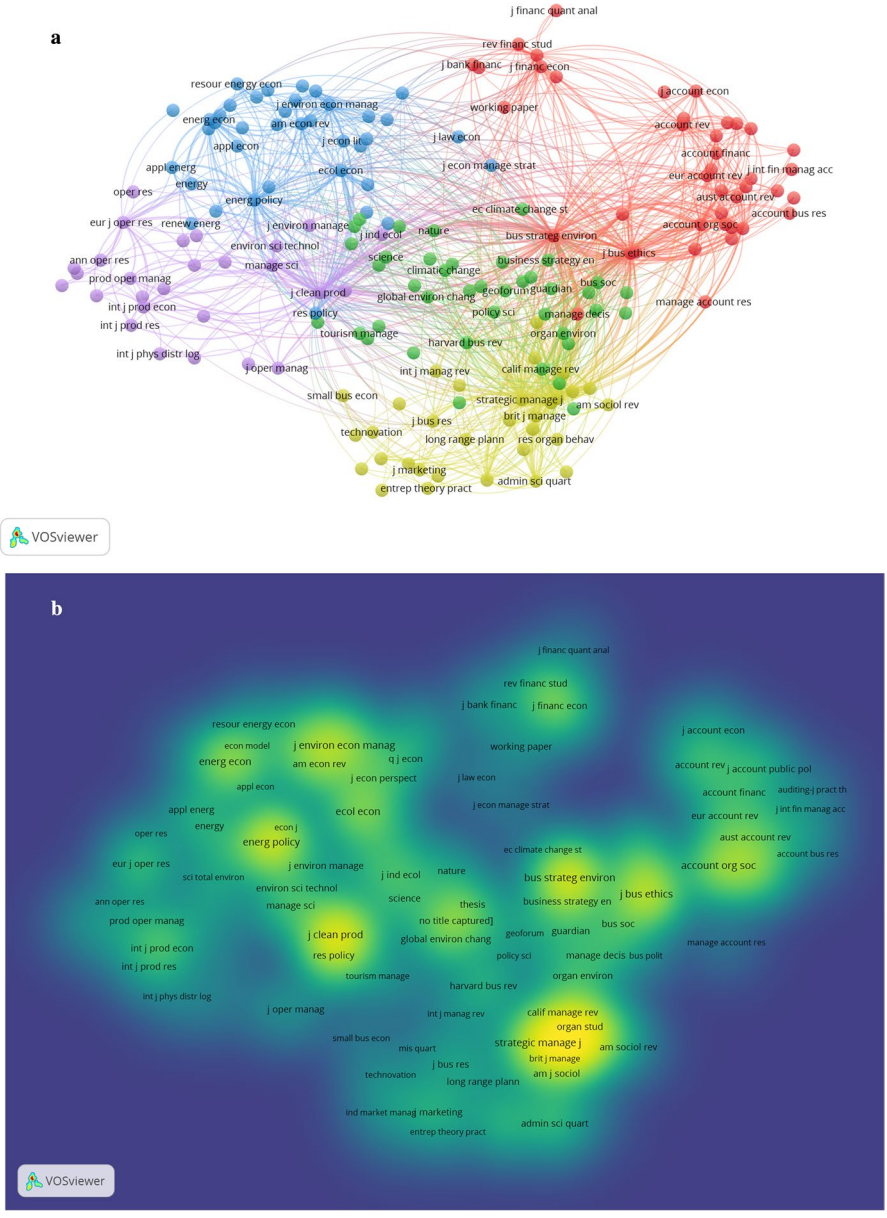


Fig. 5 Visualization of the co-citation network. *Note*: The first panel identified journal network, and second panel identified network density ($N = 1.476$ publications). Created using VOS Viewer version 1.6.17

followed by Michael E. Porter and Peter Clarkson with 262 and 196 co-citations, respectively. Table 7 shows the top ten references by co-citation. Kolk et al. (2008) was the only reference cited more than 90 times. Four references were cited more than 70 times: Porter and van der Linde (1995), Hart (1995),

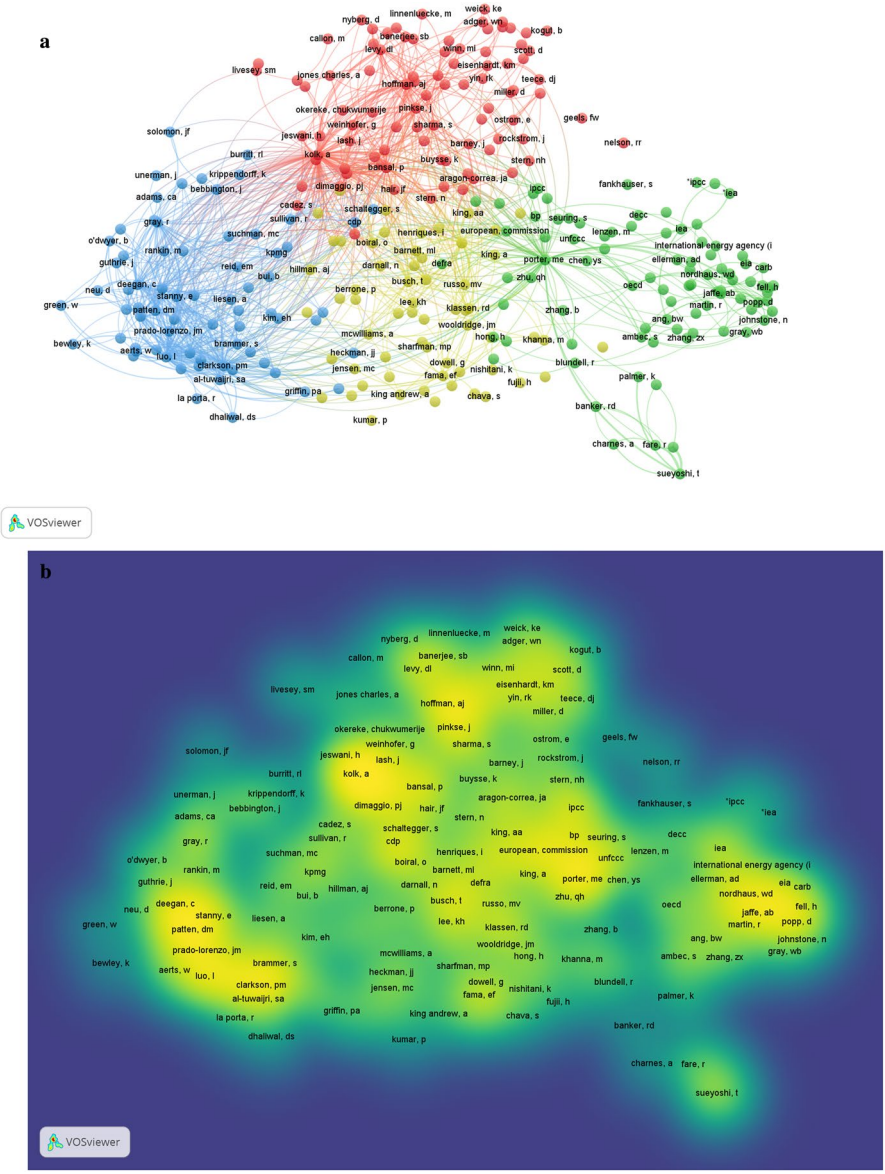


Fig. 6 Visualization of authors' network *Note*: The first panel identified author network, and second panel identified network density ($N = 1.476$ publications). Created using VOS Viewer version 1.6.17

Matsumura et al. (2014), and Clarkson et al. (2008). Among the top 10 co-citations, five were published by the top 10 authors (by co-citation). These five references are Kolk et al. (2008), Porter and van der Linde (1995), Hart (1995), Clarkson et al. (2008), and Kolk and Pinkse (2005).

Table 5 Clusters of authors

Cluster	Cluster name	Top 10 authors by cluster
Cluster 1	Business Sustainability	Kolk, A (355); Hoffman, A (162); Bansal, P (140); Levy, D (126); Pinkse, J (102); Eisenhardt, K (92); Sharma, S (92); Linnenluecke, M (89); Lee, S (82); Galbreath, J (80)
Cluster 2	Energy, Environment, and Technology	Porter, M (262); European Commission (188); Sueyoshi, T (153); IPCC (140); International Energy Agency (108); OECD (105); World Bank (101); Jaffe, A (83); Nordhaus, W (59); Popp, D (59)
Cluster 3	Environmental and Social Disclosure and Reporting	Clarkson, P (196); Luo, L (166); Deegan, C (142(; Gray, R (123); Patten, D (112); Cho, C (101); Freedman, M (98); Cormier, D (93); CDP (86); Stanny, E (85)
Cluster 4	Corporate Sustainability Strategies and Performance	Hart, S (168); Fama, E (118); Busch, T (98); Delmas, M (92); Russo, M (76); Boiral, O (71(; Klassen, R (62); Hillman, A (59); Khanna, M (57); Lee, K (56)

Table 5 presents the top 10 authors by cluster. Values in brackets represent local citations (citations within the sample). Total authors in Cluster 1:88. Total authors in Cluster 2:88. Total authors in Cluster 3: 70. Total authors in Cluster 4:61

Table 6 Top 10 Authors by co-citation

Sources	Local citations	Links	Total link strength
Kolk A	355	283	7973
Porter M	262	294	4676
Clarkson P	196	254	4902
European commission	188	254	1673
Hart S	168	279	3768
Luo L	166	216	4974
Hoffman A	162	263	3587
Sueyoshi T	153	54	769
Deegan C	142	219	3557
Bansal P	140	271	3507

Local citations refer to citations within the 1476 publications used in this study. Links refer to the number of connections within the publications. The link strength identifies the strength of the total links with a positive value

Table 7 Top 10 references by co-citation

References	Local citation	Links	Total link strength
Kolk et al. (2008)	92	112	919
Porter and Van Der Linde (1995)	80	105	434
Hart (1995)	78	111	717
Matsumura et al. (2014)	75	104	822
Clarkson et al. (2008)	70	107	878
Reid and Toffel (2009)	66	112	801
DiMaggio and Powell (1983)	60	101	478
Kolk and Pinkse (2005)	58	97	594
Al-Tuwaijri et al. (2004)	57	105	721
Russo and Fouts (1997)	57	109	553

Local citations refer to citations within the 1476 publications used in this study. Links refer to the number of connections within the publications. The link strength identifies the strength of the total links with a positive value

Kolk's most co-cited publication was "Corporate Responses in an Emerging Climate Regime: The Institutionalization and Commensuration of Carbon Disclosure" (Kolk et al. 2008). This article builds on global governance theory, institutional theory, and commensuration to explore the development of corporate reporting mechanisms for carbon disclosure. The authors suggest that carbon disclosure projects (CDP) have generated institutional pressure to disclose information on environmental impacts. According to the information recorded by the Open Research and Contributor ID (ORCID) (0000-0001-5345-2965), Kolk is a highly cited author with

more than 148 published documents since 1991. She is a full-time professor at the University of Amsterdam, Amsterdam Business School, the Netherlands. Her areas of expertise are in corporate social responsibility and sustainability (Kolk 2016; Kolk and Pinkse 2005, 2008; Muller and Kolk 2010; Pisani et al. 2017). Kolk's publications have been cited along with those by Andrew Hoffman, Pratima Bansal, and Craig Deegan (See Fig. 6 first panel).

Michael E. Porter's most co-cited publication was "Toward a New Conception of the Environment-Competitiveness Relationship" (Porter and Van Der Linde 1995). The authors suggest that adequately designed environmental policies can motivate organizational innovation offseting the cost of those policies. As firms seek innovation that increases their productivity while reducing their environmental impact, public policies can enhance industrial competitiveness. Porter is a highly cited author, with more than 400 books, articles, and book chapters published. He is a full-time professor at Harvard University, Harvard Business School, United States. His area of expertise is the competitive advantage of nations and regions, clusters and competitions, sustainable inner-city economic development, environmental policy and competitiveness, capital markets, investment, and competition (Esty and Porter 2001; Porter 1997, 1998, 2015). Porters' publications have been cited along with the research of Stuart L Hart, Andrew Hoffman, and Peter Clarkson (See Fig. 6 first panel).

The third most highly co-cited author is Peter Clarkson. His most co-cited publication was "Revisiting the Relation between Environmental Performance and Environmental Disclosure: An Empirical Analysis" (Clarkson et al. 2008). The authors build on economics and socio-political theories of voluntary disclosure to examine the relationship between environmental performance and the level of organizational environmental disclosure in a sample of polluting industries in the US. They propose that sociopolitical theories better explain patterns than economic disclosure theories. Clarkson is a full-time professor at the University of Queensland, Business School, Australia. His research areas include the voluntary disclosure of financial and non-financial outcomes, along with the economic impact of environmental performance (Clarkson et al. 2015, 2019; Jung et al. 2018).

3.3 Network analysis of keywords and key research hotspots

The frequency analysis of the authors' keywords suggests that the most common keywords in our sample were greenhouse gas emissions, sustainability, corporate performance, energy, governance, sustainable development, corporate social responsibility, environmental policy, environmental disclosure, and corporate strategy (see Table 8). The ten keywords were common in the literature as those comprise the organizational environment outcomes (e.g., greenhouse emissions and energy) (Aliouche and Schlentrich 2011; Hao et al. 2015; Haque 2017; Huang et al. 2009; Liao et al. 2015; Matsumura et al. 2014), the corporative mechanisms to deal with the negative externalities (e.g., corporate strategy, environmental disclosure, corporate social responsibility, and governance, corporate performance) (Ben-Amar et al. 2017; Foxon 2013; Hale and Roger 2014; Lattemann et al. 2009; Rankin et al. 2011;

Table 8 Ten most used keywords

Keywords	Occurrence	Merged keywords
Greenhouse gas emissions	197	Carbon emission, carbon emissions, carbon footprint, co2 emissions, emissions, ghg emissions, greenhouse gas, greenhouse gases
Sustainability	100	Corporate sustainability, sustainability
Corporate performance	65	Carbon performance, environmental performance, financial performance
Energy	45	Energy, energy efficiency
Governance	45	Corporate governance, governance
Sustainable development	45	
Corporate social responsibility	40	
Environmental policy	37	
Environmental disclosure	26	Disclosure, environmental disclosure
Corporate strategy	25	Business strategy, corporate strategy

We have excluded the keywords used in the Web of Science query, countries, continents (e.g., Australia and China), and research methods (e.g., data envelopment analysis and content analysis)

Sovacool 2011), and the institutional pressures that shape the organizational behaviour (e.g., environmental policy, sustainable development, and sustainability) (Bürer and Wüstenhagen 2009; Heutel 2012; Huang et al. 2011; Hübler et al. 2014; Ostrom 2012; Porter and Van Der Linde 1995; Revell et al. 2010).

Table 9 shows that the top ten co-citation references incorporate almost all the commonly used keywords. "corporate strategy" is the keyword used in six of the top ten references. The keywords "corporate performance," "environmental disclosure," and "sustainability" were used in five, four, and three references, respectively. Kolk and Pinkse (2005) included five keywords, moreover, Reid and Toffel (2009) and Russo and Fouts (1997) included four keywords.

Based on the co-word network, we performed a cluster detection analysis to observe the community structure within it (see Table 10 and Fig. 7). As keywords in a cluster often appear in the same research stream (Li et al. 2021), we could uncover research hotspots through an in-depth analysis of each. Thus, the conceptual space of the field is depicted. Cluster detection analysis was performed using the weighted and parameterized variant of the modularity-based clustering technique integrated in the VosViewer software (Waltman et al. 2010).

Publications in Cluster 1, the corporate environmental strategies and policies cluster, mainly focused on the set of strategic corporative decisions required to model the effect of climate change on their economic behavior. "Sustainability" was the most frequent keyword in this cluster ($n = 100$). The specific content of the publications covers topics such as stakeholder actions and regulatory threats that motivate firm adoption of sustainable practices (Heutel 2012; Reid and Toffel 2009; Tauringana and Chithambo 2015; Wright et al. 2012), the strategic organizational alternatives of firms in the face of climate change and extreme events (i.e., mitigation and adaptation), the role of environmental leadership behavior toward sustainable development (Robertson and Barling 2013; Virtanen et al.

Table 9 Top references by co-citation involving the top ten keywords

References	Keywords									
	GGE	SUS	CP	Energy	GOV	SD	CSR	EP	ED	CS
Kolk et al. (2008)									✓	
Porter and Van Der Linde (1995)										✓
Hart (1995)		✓	✓							✓
Matsumura et al. (2014)	✓		✓						✓	
Clarkson et al. (2008)			✓						✓	
Reid and Toffel (2009)		✓		✓	✓					✓
DiMaggio and Powell (1983)										✓
Kolk and Pinkse (2005)	✓	✓					✓	✓		✓
Al-Tuwaijri et al. (2004)			✓						✓	
Russo and Fouts (1997)			✓				✓		✓	✓

GGE, greenhouse gas emissions; *SUS*, sustainability; *CP*, corporate performance; *GOV*, governance; *SD*, sustainable development; *CSR*, corporate social responsibility; *EP*, environmental policies; *ED*, environmental disclosure; *CS*, corporate strategy

2013), the effect of technology and industrial power to support green transition policies (Hess 2014; Hu et al. 2020), the inherent strategic tensions faced by firms to business sustainability (Slawinski and Bansal 2015), and the development of "green" organizational advantages (Kolk et al. 2008).

The article titled "Climate Change Policy, Market Structure, and Carbon Leakage" (Babiker 2005) was the most cited in Cluster 1. The document explores the market structure effect induced by the OECD abatement of GHGs on the geographic distribution of energy-intensive production, trade, and leakage (pp. 422). Babiker (2005) found that GHGs abatement policies lead to significant increases in offshore energy-intensive production associated with the relocation of firms, plus an intensification in global GHG emissions (pp. 441).

The second highly cited article in Cluster 1 is "Stock Prices of Clean Energy Firms and Oil and Carbon Markets: A Vector Autoregressive Analysis" (Kumar et al. 2012). This study examines the relationship between oil prices, stock prices of clean energy firms, and prices of alternative energy products (pp. 216). The authors found that the variations in the indices of clean energy stocks are explained by variations in oil prices, stock prices of high-technology firms, and macro indicators (i.e., interest rates) (pp. 225).

The third highly cited article in Cluster 1 is "Adaptive Fit Versus Robust Transformation: How Organizations Respond to Environmental Change" (Lengnick-Hall and Beck 2005). In this article, Lengnick-Hall and Beck (2005) theorized how organizations adapt to uncertainty and environmental changes (p. 738). The authors advocate that the assumptions regarding organizational adaptive fit under uncertainty were insufficient to understand how organizations react to external changes (p. 739). Therefore, to close that theoretical gap, they introduced the multidimensional construct of resilience capacity at the organizational level (pp. 750). The authors

Table 10 Clusters of keywords

Cluster	Cluster name	Main keywords
Cluster 1	Corporate environmental strategies and policies	Sustainability, energy, corporate strategy, climate policy, innovation, renewable energy, circular economy, mitigation, risk, resilience
Cluster 2	Corporate environmental outcomes and reporting	Greenhouse gas emissions, corporate performance, carbon disclosure, environmental reporting, carbon accounting, voluntary disclosure
Cluster 3	Corporate environmental pressures	Sustainable development, environmental policy, institutional theory, stakeholder engagement, environmental sustainability
Cluster 4	Corporate governance and environmental management	Governance, corporate social responsibility, environmental disclosure, environmental management
Cluster 5	Environmental finance	Carbon tax, emissions trading, investment

Fig. 7 Visualization of keyword network. *Note*: the first panel illustrates the network of keywords, ▶ the second panel exhibits the network's evolution, and the third panel shows the density of keywords ($N = 1.476$ publications). Visualization of keywords with more than 10 occurrences. Created using VOS Viewer version 1.6.17

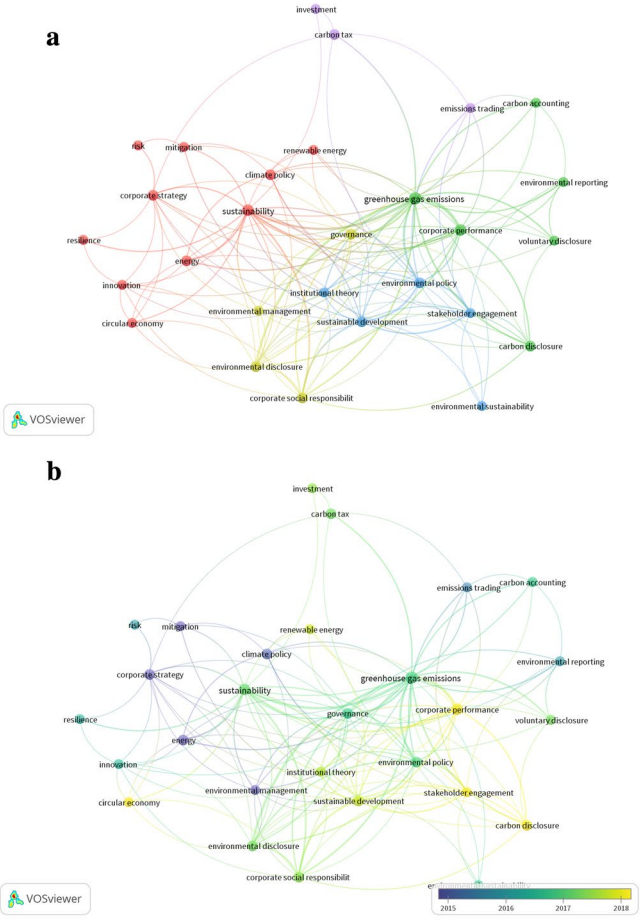
theorized that resilience capacity is a learned capacity that allows organizations to interpret and confront unknown situations by mobilizing people, resources, and processes (p. 751).

Publications in Cluster 2, the corporate environmental outcomes and reporting cluster, mainly focused on how organizations report and disclose their environmental impact. "Greenhouse gas emissions" ($n = 197$) was the most frequent keyword in this cluster. The publications explored research topics such as how organizations cooperate through innovation to reduce abatement costs (Yang and Chen 2018), how environmental management policies affect financial performance (Iwata and Okada 2011), how firms' environmental efforts relate to corporate market valuation (Fisher-Vanden and Thorburn 2011), how organizations develop legitimacy management strategies foot-print related discourses (Hrasky 2012), how organizations should approach and disclose their greenhouse emissions (Ben-Amar et al. 2017; Huang et al. 2009; Kuo et al. 2012), and how organizational exposure to carbon-related risks and carbon awareness affects the cost of financing and financial returns (Gallego-Álvarez et al. 2014; Jung et al. 2018; Oestreich and Tsiakas 2015).

The article titled "CO_2 Emissions, Energy Consumption, Trade and Income: A Comparative Analysis of China and India" (Jayanthakumaran et al. 2012) was the most cited in Cluster 2. The document evaluates and compares the Environmental Kuznets Curve framework for CO_2 and energy consumption in the Chinese and Indian contexts (p. 451). Jayanthakumaran et al. (2012) concluded that growth and structural changes in the ratio of the manufacturing sector to GDP could have influenced CO_2 emissions in China (pp. 459). Nonetheless, in the Indian context, the authors suggest that emissions are driven by the energy consumption of the informal economy and microenterprises (p. 459).

The second highly cited article in Cluster 2 is "Managing New and Remanufactured Products to Mitigate Environmental Damage under Emissions Regulation" (Yenipazarli 2016). The research explored (a) the effectiveness of the emission regulation in making remanufacturing achieve a win–win situation in which the organizational economic and environmental goals are congruent, and (b) the impact of distinguishing features of remanufactured products and the society-related factors in balancing profits with environmental and social impact (pp. 128). The author concludes that imposing an emissions charge can make it profitable for the manufacturer to introduce a remanufactured good in its product line (p. 129). In addition, emission charges offer an effective approach to reducing total emissions by remanufacturing (p. 129).

The third highly cited article in Cluster 2 is "Reductions in Greenhouse Gas Emissions and Cost by Shipping at Lower Speeds" (Lindstad et al. 2011). The authors modelled the shipping industry CO_2 emissions and its relationship with the operation of the global maritime feet (i.e., lower vessel speed) using shipping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renewable energy
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corporate performance
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resilience
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innovation
environmental policy
institutional theory
environmental management
stakeholder engagement
circular economy
sustainable development
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stakeholder engagement
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movement information between Asia and Europe (pp. 3457). Lindstad et. al. (2011) suggests that achieving minimum emissions by reducing vessel speed would lead to an increase in shipping costs and a positive abatement cost (pp. 3462).

Publications in Cluster 3, the corporate environmental pressures cluster, aimed to analyze the macro tensions (e.g., environmental policies) and firms' social determinants (e.g., stakeholder engagement) to be involved in environmental endeavors. The most frequent keyword in this cluster was "sustainable development" ($n=45$). The articles examined topics related to how organizations are willing to accept the cost of environmental taxes due to potential savings and value increases (Foxon 2013; Revell et al. 2010), how massive environmental discontinuous changes (e.g., intense storms, floods, droughts, fires, sea level rise) caused by climatic change motivate firms to respond and adapt (Winn et al. 2011), how regulation and demand pressures can motivate eco-innovation in firms (Doran and Ryan 2016; Haddock-Fraser and Tourelle 2010; Porter and Van Der Linde 1995), and the role of stakeholder pressures in determining an environmental strategy (Aliouche and Schlentrich 2011; Escobar and Vredenburg 2011; Haque and Ntim 2018; Pinkse and Kolk 2012; Sprengel and Busch 2011).

The article titled "Greening Organizations through Leaders' Influence on Employees' Pro-environmental Behaviors" (Robertson and Barling 2013) was the most cited in Cluster 3. Robertson and Barling (2013) developed and tested a model that explored how leaders' environmental behavior influences employees' harmonious environmental behavior and passion. Robertson and Barling (2013) observed that when transformational leadership encourages environmental initiatives, employees increase their pro-environmental behavior (p. 12). Moreover, their model suggests that transformational leadership and leaders' workplace pro-environmental behavior independently and significantly predict employees' environmental passion (p. 13).

The second highly cited article in Cluster 3 is "Which Renewable Energy Policy is a Venture Capitalist's Best Friend? Empirical Evidence from a Survey of International Cleantech Investors" (Bürer and Wüstenhagen 2009). The article explores which policies are perceived to be more effective in investing in innovative clean energy technology firms (pp. 4998). The authors observed that policies such as feed-in tariffs are especially effective in stimulating investors' interest in new renewable energy technologies (pp. 5005). Moreover, they pointed out the active governmental role of incentivizing technology-push (e.g., grants) and market-pull policies (pp. 5005).

The third highly cited article in Cluster 3 is "Voluntary Agreements to Improve Environmental Quality: Symbolic and Substantive Cooperation" (Delmas and Montiel 2009). The article explores collective corporate political strategies through voluntary environmental agreements between organizations and regulatory agencies (pp. 576). Delmas and Montes-Sancho (2010) found that early joiners and later joiners of the program adopted different types of cooperative behavior (p. 595). These behavioral differences were explained by the different institutional pressures experienced by the participants and their previous investment in environmental improvements (p. 595).

Publications in Cluster 4, the *corporate governance and environmental management* cluster, primarily addressed the ESG determinants of sustainable organizational behavior. The most frequent keyword in this cluster was governance ($n=45$). Publications in the cluster explored phenomenon as the role of the board of directors and the board characteristics (e.g., effectiveness, number of directors, and independence in board chair) in the disclosure of organizational environmental outcomes (e.g., greenhouse gases) and organizational environmental risks (Ben-Amar and McIlkenny 2015; Galbreath 2010; Prado-Lorenzo and Garcia-Sanchez 2010; Sovacool 2011), and the role of distinct climatic governance initiatives (e.g., local, transnational, or intergovernmental) as a collective form of reducing greenhouse gas emissions (Hale and Roger 2014; Pinkse and Kolk 2012).

The article titled "Responding to Public and Private Politics: Corporate Disclosure of Climate Change Strategies" (Reid and Toffel 2009) was the most cited in Cluster 4. This study explores corporate responses to shareholder activism (pp. 1157). The authors built a model to assess whether and how experience with politics might influence organizational responses to shareholder groups (p. 1158). Based on the results, the authors concluded that (a) organizations respond to private politics by adopting new practices that adhere to the underlying objective of social activists (pp. 1171), and (b) shareholder activism can spur industry-wide changes in organizational practices (pp. 1172).

The second highly cited article in Cluster 4 is "Shared Producer and Consumer Responsibility - Theory and Practice" (Lenzen et al. 2007). The article discusses a method to delineate the supply chain footprint of actors in an economy (p. 39). Lenzen et. al. (2007) developed a *shared responsibility delineation method* that emphasizes the role of every supply chain member to enter a dialogue on how to reduce overall GHG performance. In this method, each member is affected by the upstream supplier footprint and affects the downstream recipient (p. 36).

The third highly cited article in Cluster 4 is "Gender Diversity, Board Independence, Environmental Committee, and Greenhouse Gas Disclosure" (Liao et al. 2015). The study examines the impact of the corporate board of directors' characteristics on the voluntary organizational disclosure of GHG emissions (p. 2). Liao et al. (2015) find that the proportion of female directors on the board is strongly correlated with the propensity and level of disclosure (p. 13). The existence of an environmental committee and the proportion of independent directors are linked to disclosure propensity (p. 13).

Finally, publications in Cluster 5, the *Environmental Finance* cluster, examined the relationship between fiscal (e.g., carbon taxes) and financial instruments (e.g., emission trading schemes) with organizational performance. The most frequent keyword in the cluster was carbon tax ($n=22$). Research on environmental finance included the impact assessment of the firm market valuation based on its carbon intensity profile (Chapple et al. 2013), the measurement of "carbon premium" and "carbon risks" in financial assets (Oestreich and Tsiakas 2015; Yoshino et al. 2021), and the evaluation of fiscal mechanisms (e.g., emission trading systems and carbon taxes) to reduce corporate greenhouse gas emissions (Bao et al. 2013; Benavente 2016; Cao et al. 2020; Mathur et al. 2003; Smith and Swierzbinski 2007; Van Asselt and Biermann 2007; Wittneben 2009).

The article titled "Environmental Externalities and Cost of Capital" (Chava 2012) was the most cited in Cluster 5. This study examines the effect of the organizational environmental profile and its cost of equity and debt capital (p. 1). The author found a positive relationship between net environmental organizational concerns and the expected returns of its stocks (p. 4). In addition, organizations with climate change concerns have higher costs of equity and debt capital (p. 37).

The second highly cited article in Cluster 5 is "Retailer-driven Carbon Emission Abatement with Consumer Environmental Awareness and Carbon Tax: Revenue-Sharing Versus Cost-Sharing" (Yang and Chen 2018). The authors investigated the impact of revenue-sharing and cost-sharing offered by a retailer on the manufacturer's carbon emission abatement efforts (pp. 3). Yang and Chen (2018) found that retailers can move first to offer incentive schemes to the manufacturer (e.g., sharing revenue and investment, both, neither). Finally, the third most cited article in Cluster 5 is "The Cost of Carbon: Capital Market Effects of the Proposed Emission Trading Scheme (ETS)" (Chapple et al. 2013). The authors investigated the stock pricing effects of the Emission Trading Scheme (ETS) within the Australian market (p. 1). Chappel et al. (2013) found direct evidence that the market appears to assess a market value penalty for firms with high carbon intensity (p. 30).

4 Implications, empirical gaps, and further research opportunities

Employing two complementary bibliometric methods (i.e., co-citation and co-word network analysis), we provide an overview of the intellectual and conceptual space of this line of inquiry. An overview of our results indicated that this field is highly concentrated. For instance, most of the productivity has been concentrated in the last five years (Sect. 3.1.1), with two regions, Europe and the USA, accounting for more than 65% of the total published papers (Sect. 3.1.2). Regarding sources, most of the articles were published in a few journals (Energy Policy, Business Strategy and the Environment, and Energy Economics), whereas only two of the top-10 authors were co-cited more than 200 times (Sect. 3.2). Because of these structural features, we were able to distinguish five research hotspots in the literature (Sect. 3.3). The high concentration uncovered here could be explained by the fact that climate change is a relatively new field of study within the business, economics, and management categories. At the same time, this feature could provide fertile ground for new research opportunities.

Based on this examination, several research gaps were identified. First, further empirical research on this topic could explore understudied regions (e.g., Central America, South America, the Middle East, and Africa) where there is a lack of understanding of the phenomenon. This is a severe gap in the literature, as the evidence suggests that these regions are among the most vulnerable to climate change impacts (Adelekan et al. 2022; Castellanos and Lemos 2022; Hennessy et al. 2022; IPCC 2022). Moreover, two prominent journals, based on the most considerable quantity of articles (i.e., *Energy Policy* and *Energy Economics*), focused on energy-related mitigation strategies.

We propose to delve into other organizational approaches (e.g., network-based adaptation, transformation, or resilience) used to cope with the effects of climate change on socio-ecological systems. Therefore, a fruitful avenue of inquiry could be to evaluate how highly natural-resource-dependent countries, industries, and sectors transform their value chain processes in the face of climate stressors. Finally, we noted a shortage of research on how extreme weather events alter the long-term decision-making process of the firm, how they impact organizational performance, and how top management teams perceive this dynamic process.

Second, the role of organizational adaptation to climate change has not received considerable attention in the literature (Adenle et al. 2017; Bremer and Linnenluecke 2017; Crick et al. 2018; Linnenluecke and Griffiths 2010; Ng et al. 2018; Rivera and Clement 2019). In addition, most research on this topic has focused on reactive, rather than planned, adaptation (Gasbarro and Pinkse 2016; Reed et al. 2013). Further research could delve into the complementarities and trade-offs between adaptation strategies and organizational performance. Moreover, some authors suggest that resilience, as the core concept of adaptation, is significant in understanding how organizations generate decision-making processes, business practices, and strategies to deal with natural environmental changes (Herweijer et al. 2009; Linnenluecke and Griffiths 2010). Additional examination is required to understand the set or "bundle" of capabilities and response approaches that enhance organizational resilience and reduce a firm's vulnerability to climate variability. Lastly, it is necessary to explore how managers' perceptions of climate change could affect a firm's adaptive behavior.

Third, the role of environmental policies and corporate environmental pressure requires further research. Initially, it was necessary to understand the effect of economic shocks and business cycles on the efficient adoption of national and regional corporate environmental policies (Heutel 2012). Moreover, investigating the temporal dynamics of public policy could contribute to understanding how institutional pressures motivate organizations to pursue environmental efforts (Reid and Toffel 2009). In addition, research focusing on the effects of national and international environmental disclosure regulations and their relationship with voluntary greenhouse gas emissions could prove the efficiency of these governmental efforts (Tauringana and Chithambo 2015). Moreover, it is worth examining the role of the predominant economic and industrial power/influence in sustainability transitions to lower-emission economic activity (Hess 2014). Finally, empirical examinations following the argument made by Porter and van der Linde (1995), which concentrates on the effect of several environmental policies on a firm's innovation outcomes, could enhance our awareness of the role of governments in promoting innovation (Hu et al. 2020).

Fourth, corporate environmental outcomes require further examination. Understanding the strategic interaction and decisions between firms that cooperate in eco-innovation endeavors could provide insights to motivate emissions abatement (Yang and Chen 2018). Similarly, delving into the short- and long-term effects of environmental management decisions on corporate valuation could contribute to understanding the role of market mechanisms in aligning organizational incentives (Fisher-Vanden and Thorburn 2011; Iwata and Okada 2011). Lastly, empirical

research exploring the longitudinal relationship between financial and environmental firms' performance could contribute to the debate on how corporations decide their strategic position in the face of contexts affected by climate change (Gallego-Alvarez et al. 2014).

Finally, the roles of corporate governance and environmental management must be explored further. In particular, it is not clear how different corporate governance structures (i.e., corporate board characteristics and stakeholder practices) contribute to detecting and reacting to environmental tensions originating from climate change (Ben-Amar et al. 2017; Galbreath 2010). Likewise, further research could explore how organizations can achieve a competitive advantage by setting environmental policies and practices (Frerichs and Teichert 2021; Guillén et al. 2021). Finally, it is necessary to conduct a comparative analysis of how top management teams and the board of directors disclose environmental information as a reactive strategy to environmental pressures (Bhatt and Ghuman 2022; Prado-Lorenzo and Garcia-Sanchez 2010).

Further research could expand our bibliometric analysis, including additional databases (e.g., Scopus and Google Scholar) as well as non-English language journals. Moreover, framework analysis (e.g., Theory, Contexts, and Methods framework; Antecedents, Decisions, and Outcomes framework), and thematic in-depth literature reviews could provide additional insights into this research area. Lastly, future research could explore the co-citation and co-word network evolution in a longitudinal setting to delve into the changes in the intellectual and conceptual space of the field.

5 Conclusions and limitations

Although research on organizations and climate change has gained relevance, little is known about its academic evolution. This study contributes to the extant literature by conducting a state-of-the-art subject review. Our research answered the following questions: What is the evolution of the subject in the 1999–2021 period? Which are the leading research organizations and prominent journals contributing to this subject? Who are the main authors? What thematic clusters are found in the literature? Which theme lacks research and require further attention? Several conclusions can be drawn from this analysis. First, scholarly interest in this topic has increased since 1999, achieving momentum in 2021 when 271 publications were published. The University of Queensland, Australia, is the most productive research organization, and Europe has the highest publication density. *Energy Policy* is the most productive journal, providing a platform for high-quality research on this subject.

Ans Kolk and Michael E. Porter are the most co-cited authors. According to the cluster analysis, keywords could be catalogued into six clusters: corporate environmental strategies and policies, corporate environmental outcomes and reporting, corporate environmental pressures, corporate governance and environmental management, and environmental finance. Research on this subject will expand on these major themes. Finally, empirical research exploring the dynamics of environmental policies in organizational behavior and outcomes, the strategic interaction between

organizations in the face of environmental pressures, and the firm's internal determinants to disclose and engage in environmental tensions is expected to expand our understanding of the subject.

Our study had some limitations. First, this paper has analyzed the scientific research on organizations and climate change based on peer-reviewed articles in English language journals; then, our analysis does not consider certain types of documents (e.g., editorial materials, books, book chapters, books review) and languages (e.g., Spanish, Portuguese, French). In addition, bibliometric analysis was restricted to the WOS database because of its quality and support in prior research. Finally, our objective was to provide a descriptive analysis; therefore, we did not provide an in-depth analysis of the subject.

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Author contribution JADT: Conceptualization, methodology, software, formal analysis, resources, data curation, visualization, writing (original draft), and writing (review and editing). MJHS: Conceptualization, validation, formal analysis, data curation, and writing of the original draft. RDPO: conceptualization, methodology, writing - review and editing, supervision, project administration, funding acquisition.

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Data availability The dataset used in this study is available at https://doi.org/10.17632/bb6fx9swjx.1. Additional materials can be requested from the corresponding author.

Declarations

Conflict of interest This manuscript has not been published or presented elsewhere and is not under consideration by another journal. All authors have approved the manuscript and agree with submission. The authors have no relevant financial or non-financial interests to disclose.

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