Trends on Carbon Footprint and Climate Change Research: A Bibliometric Study from 2000 to 2022

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Abstract:

In recent years, global scientific interest in Carbon Footprint (CF) analysis to mitigate Climate Change (CC) has significantly increased. The present work aims to apply a bibliometric study in order to analyze the research trends in the field of carbon footprint and their contributions in climate change during the period 2000-2022. Our analysis based on the WoS database, based on 3459 articles, and revealed that scientific research on carbon footprint and their contributions in climate change is a relatively recent thematic of research which appeared in the last two decades. Although the number of publications has grown over the years, scientific production is still limited and evolves much slower in many countries. USA, China, UK, Australia and Germany are the leading research production in this field totalizing together over 60% of the total scientific production.

The main topics addressed in the scientific literature under this thematic are related to life cycle assessment followed by greenhouse gases emissions and sustainable development.

Keywords: Carbon footprint, Climate change, bibliometric study, Web of science.

Introduction

Increasing greenhouses gases (GRG) in the atmosphere resulting from human activity will exacerbate the trend of general warming observed at the global scale and has significant negative effect on environment and the economy [1, 2 ,3, 4]. Therefore, it is clear that the climate change (C.C) is one of the primary challenges from the planet earth in the twenty-first century [5]. Indeed, GHG includes carbon dioxide, methane and nitrous oxide. Carbon dioxide contributes the most to global warming [6].

Nevertheless, in spite of the expected adverse effects of climate change, it is still possible, using a wide array of technological measures and changes in behavior, to mitigate CC impacts through building a new economy in ways that are clean, green and safe [7,8,9].

In order to achieve this goal, one of the climate positive actions proposed by the UN is the adoption of green transition through investments that should accelerate the decarbonization of all aspects of economy and the reduction of GHG emissions, notably Carbon dioxide [10]. Against this backdrop, the carbon footprint (CF), a key metric of greenhouse gas emissions, has gained more significance in recent years as a result of the simultaneous pressures of global warming and international agreements to lessen its consequences [11, 12,13]. Indeed, as an important indicator of greenhouse gas emissions, the (CF) is a measure of the impact your activities have on the amount of carbon dioxide (CO_2) produced through the burning of fossil fuels and is expressed as a weight of CO_2 emissions produced in tones [14, 15, 16]. It has been crucial in raising public awareness of climate change and the need to reduce carbon emissions. It has also served as a springboard for fostering social environmental consciousness and minimizing the environmental impact of systems and products [13].

Accordingly, the present study aims to a apply a bibliometric approach in order to analyze the trends in the field of Carbon footprint analysis to mitigate the Climate Change over the period 2000–2022.

Material and methods

1. Data source and collection

The bibliometric study was conducted for the selected period of years from 2000 to 2022 using the Web of Science (WoS) database. This later was used since it is well recognized as a reliable source of information around the world. Moreover, the WoS core collection database houses tens of thousands of highly regarded research articles on a variety of topics, including management, engineering, economics, and agronomy [13]. As a result, using WoS as the study's data source is both rational and efficient. The terms " carbon footprint " and "climate change" were searched for in the titles and abstracts of WoS articles published from 2000 to 2022. Our search strategy produced 3459 papers on the subject of carbon footprint (CF) and climate change (CC).

2. VOSviewer

In our study, we used the VOSviewer software to analyze and visualize our data. Since it enables users to build and examine bibliographic networks, VOSviewer is a well-liked tool for performing field-specific bibliographic analysis.

Results and discussion

1. Chronological trend of the research

Between 2000 and 2022, 3459 articles were published in the disciplines of "carbon footprint "(CF) and "climate change" (CC), according to Web of Science. The annual publishing numbers for the CF and CC papers are shown in Figure 1 and exhibit a general trend of growth throughout time. Three phases of the trend can be identified: 2000–2007, 2008–2017, and 2018–2022. There was a dearth of exploratory activities between 2000 and 2007. Before 2007, there were 2.62 articles produced on average per year, and the number of publications grew gradually. Research on footprint carbon and climate change was still in its infancy, which suggests that the majority of scientists were not aware of its importance. Between 2008 and 2017, an average of 115.3 papers per year were published, a 44-fold increase from 2000 to 2007. This suggests that an era of rapid growth has begun for the scientific community. The high-yield period was active and fruitful, with an average yearly publishing output of 457 articles between 2018 and 2022. The rise in the publication number can be explained by the signing of the Copenhagen Climate Agreement in 2009. The countries who voluntarily signed up to the Accord represent 188 percent of global emissions. Additionally, the Paris Agreement, which was ratified in 2016, was the first occasion when nations decided to take action to stop climate change and prepare for its effects. As a result, global scholars are become more and more worried about carbon footprint and climate change.
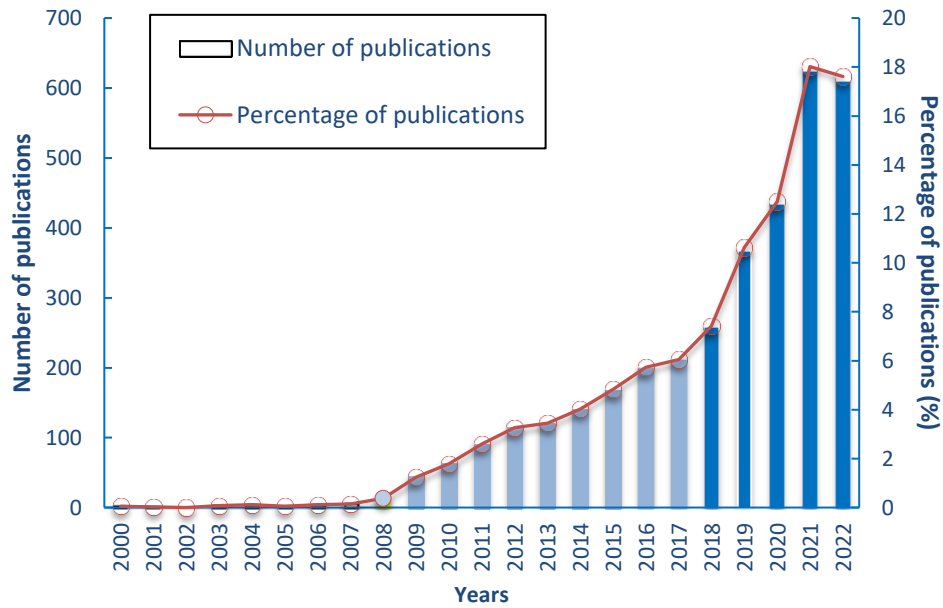
Figure 1: Number of articles on carbon footprint and climate change between 2000 and 2022

2. Geographical distribution of Fc and CC articles

Figure 2 shows a visualization of the publications distribution on a map by nation. The node's circle size indicates the frequency of the country; the bigger the diameter, the higher the frequency.

The United States had the most articles published (767), followed by China (506), the United Kingdom (394), Australia (271), and Germany (244), representing 63% of total publications research for those five most productive countries (figure 2).
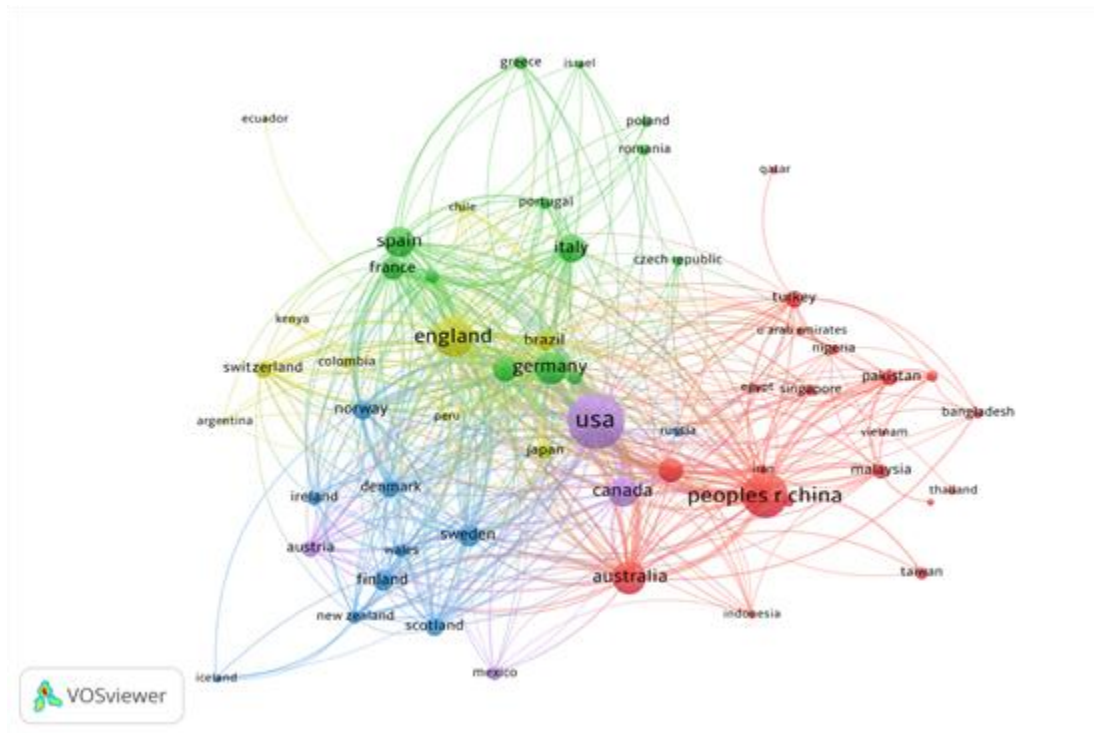

Figure 2: Distribution of CF and CC papers by country

3. Analysis of document types and languages

According to the bibliometric analysis, articles make up 79% of all published papers, followed by review articles (9%) and proceedings papers (8%) (figure 3). Nearly majority of the 3459 publications (99%) that were published were in English, according to the statistics in figure 4.
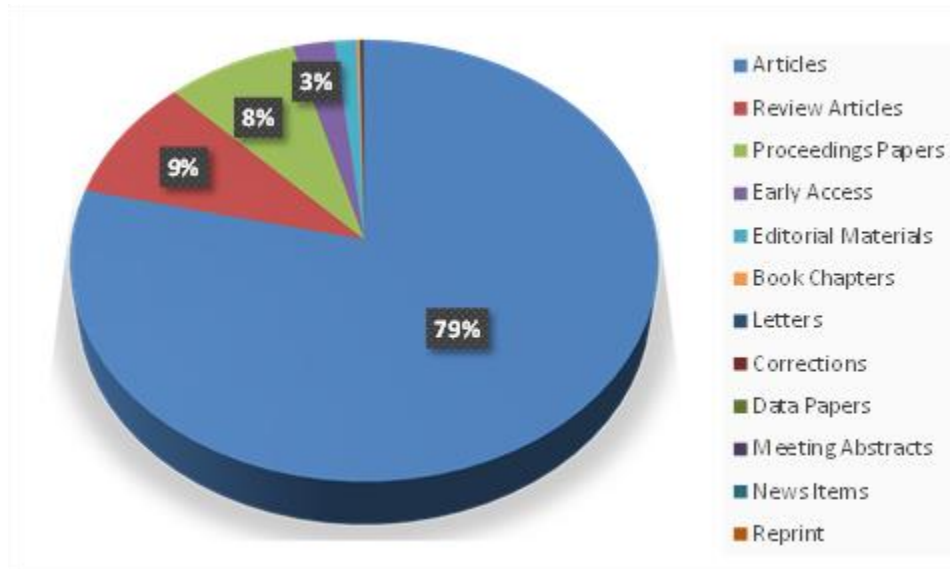

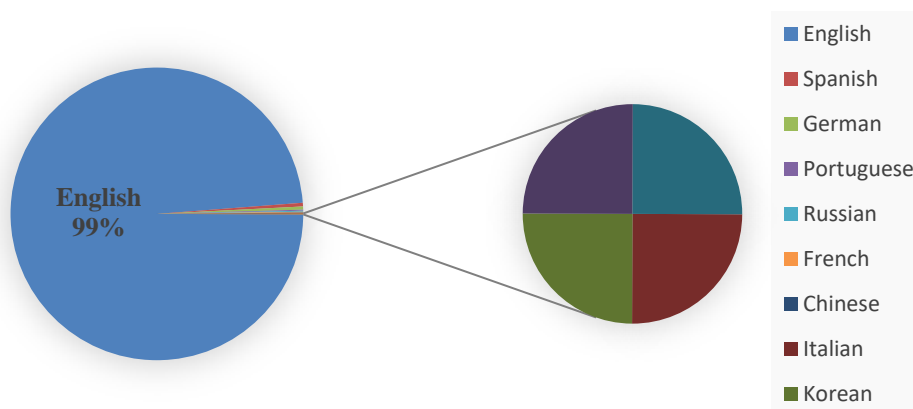**Figure 3:** Distribution of document types.

Figure 4: Language distribution for CF and CC research.

Research techniques, research objects, and research contents are represented by keywords, which, to some extent, represents the discipline structure of the document [17]. To extract the keywords that best reflect the main ideas of the literature, the keywords should be clustered. This will help you better grasp the hot themes in CF and CC research. The more common the term in the cluster and the more relevant it is to the issue, the larger the node [13].

According to the clusters' keywords, the focus of the work on the CF and CC was mostly on the three characteristics: life cycle assessment, greenhouse gas emissions and sustainable development.

The life cycle assessment (LCA) approach is the most often used method for determining CF in extant research. LCA is a methodology framework that has developed into a technology for thoroughly assessing how products or systems affect the environment and energy use [18]. It uses quantitative analysis to examine environmental issues in the present with objectivity. The "cradle-to-grave" study is used to evaluate the environmental impact of a process, a product, or an activity across the course of its existence [19]. The LCA calculation technique is reasonably precise and thorough, and each activity's specifics may be quantified. It is appropriate for the calculation of CF at the micro level and completely takes into account the entire integrity and comprehensiveness of the carbon dioxide emission measurement calculation process. It is primarily focused on goods and services right now. According to [20], the LCA has been implemented in a representative manner to determine the CF of dairy products. The complete lifecycle of the specified product or process is documented using a basic flowchart, and the boundary of the CF calculation system is defined in accordance with the circumstances.
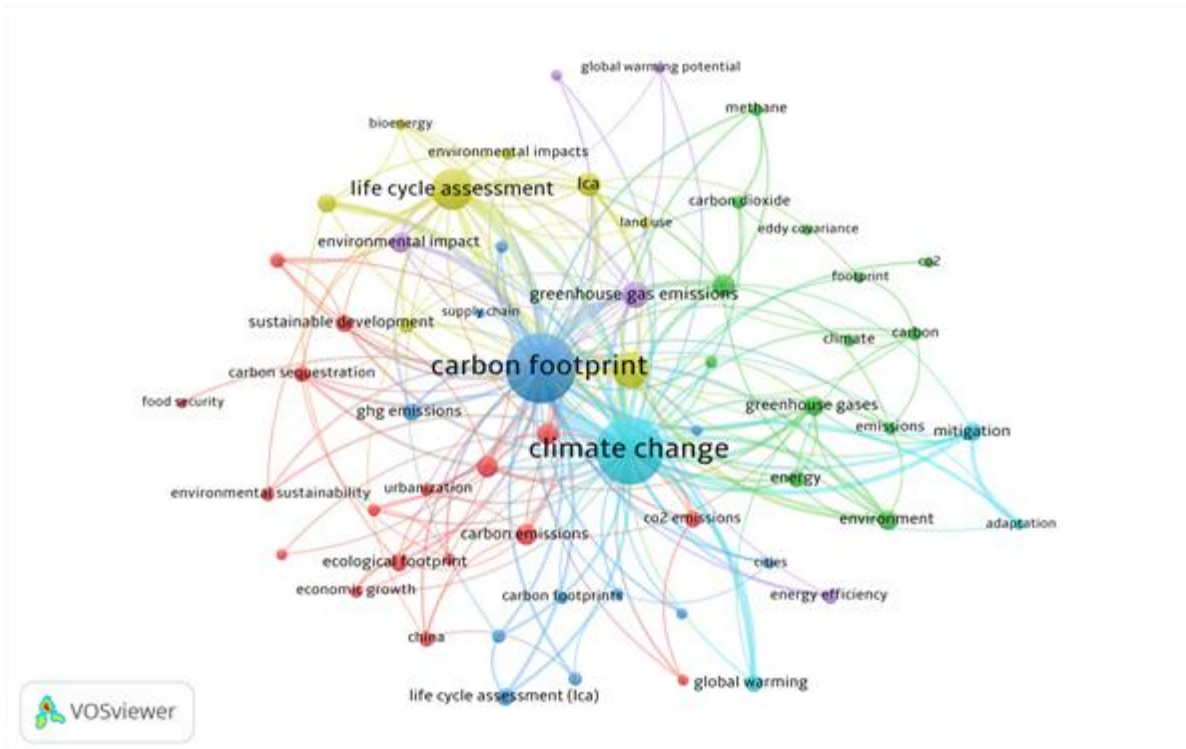

Figure 5: Keyword clustering diagram for CF and CC research.

4. Most productive authors

According to the bibliometric analysis, Ahmad Sajjad from University of Nevada (Las Vegas) is the most prolific author, followed by Junnila Seppo (Aalto University, Finland), Heinonen Jukka (University of Iceland), and Wiedmann Thomas (UNSW Sydney, Australia) (Table 1).

Table 1 Top 10 most productive authors on Fc and CC research.

Author	Number of publications	Percentage of 3459 (%)
Ahmad Sajjad	19	0.55
Junnila Seppo	18	0.52
Heinonen Jukka	15	0.43
Wiedmann Thomas	15	0.43
Lenzen Manfred	15	0.43
Hertwich Edgar G	15	0.43
Feijoo Gumersindo	13	0.38
Moreira Maria Teresa	13	0.38
Gonzalez-Garcia Sara	12	0.35
Styles David	12	0.35

Conclusion

The present bibliometric analysis of published articles between 2000 and 2022 revealed that scientific research on Carbon footprint analysis is relatively a young thematic of research which started in the last two decades. Although the number of publications has grown over the years, scientific production is still very limited and evolves much slower in many countries. USA, China and UK are the leading research productions in this field.

Our findings indicate that the research on Carbon footprint analysis to mitigate the Climate change being limited in space and suffer from large data gaps especially in MENA countries. Thus, it is necessary to further develop research and foster collaboration between researches

In addition, the main topics covered in the scientific literature under the theme Climate Change have been interested in the causes and consequences of greenhouse gas emissions
Most of these studies have examined the influence of Climate Change on warming, floods and droughts, sea level rise, forecast scenarios of climate change while how the development of carbon footprint methodology in different sectors can mitigate C.C has not received much attention so far.

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