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Global Academic Perspective on Carbon Footprint and Climate Change Studies

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ABSTRACT

Since the Industrial Revolution, human activities have significantly impacted the climate system, alongside natural climate variability. Transitioning to a low-carbon economy has become a global priority, and the concept of carbon footprint has gained prominence due to the critical role of CO_2 emissions. Climate change is one of the most significant global challenges facing the world today, primarily driven by greenhouse gas emissions. Among these gases, carbon-based emissions account for the largest share. Reducing carbon emissions is of critical importance in combating climate change, and in this context, the assessment of carbon footprints has increasingly become an important area of research. This study analyzes scientific trends in climate change and carbon footprint research by examining publications from 2010 to 2025 in the Scopus and Web of Science (WOS) databases. A total of 9,335 articles in Scopus and 6,642 in WOS were initially identified, from which 111 publications were selected for detailed analysis. The data obtained reveal the interdisciplinary nature of this subject and its significance in scientific research. Findings indicate a notable increase in both the quantity and depth of research in this field. Bibliometric analysis highlights that studies are mainly concentrated in environmental engineering and sustainable development, while social sciences remain underrepresented. The majority of publications originate from the USA, China, and Germany, pointing to the need for capacity-building in developing countries. Frequently used keywords include ‘‘sustainability,’’ ‘‘renewable energy,’’ and ‘‘greenhouse gas emissions,’’ suggesting these topics will remain central in future research. The study also identifies knowledge gaps and understudied areas, providing quantitative insight into the development and focus of academic studies. Overall, this research offers a strategic perspective for guiding future investigations and understanding global trends in efforts to mitigate climate change and promote sustainability.

Keywords: *Climate Change, Carbon Footprint, Bibliometric Analysis*

Karbon Ayak İzi ve İklim Değişikliği Çalışmalarının Küresel Akademik Perspektifi

ÖZET

Sanayi Devrimi'nden bu yana, doğal iklim değişikliklerine ek olarak insan faaliyetleri iklim sistemini önemli ölçüde etkilemiştir. Düşük karbonlu ekonomiye geçiş, küresel ısınma ve iklim değişikliğiyle mücadelede küresel öncelik haline gelmiş; CO_2'nin etkisi nedeniyle karbon ayak izi kavramı da araştırmaların odak noktası olmuştur. İklim değişikliği, günümüz dünyasının en önemli küresel sorunlarından biri olup, temel nedeni sera gazı emisyonlarıdır. Bu gazlar içerisinde karbon türevleri en büyük paya sahiptir. İklim değişikliğiyle mücadelede karbon salınımının azaltılması kritik bir öneme sahiptir ve bu bağlamda karbon ayak izinin belirlenmesi giderek artan bir araştırma alanı haline gelmiştir. Bu çalışma, 2010-2025 yılları arasında Scopus ve Web of Science (WOS) veri tabanlarında yayınlanan makalelerin bibliyometrik analizini sunarak akademik eğilimleri değerlendirmektedir. Ocak 2025'te yapılan aramada Scopus'ta 9.335, WOS'ta 6.642 makale tespit edilmiş; bunlardan 111'i detaylı inceleme için seçilmiştir. Elde edilen veriler, konunun disiplinler

arası niteliğini ve bilimsel araştırmalardaki önemini gözler önüne sermektedir. Bulgular, yayınların sayıca artmakla kalmayıp içerik açısından da derinleştiğini göstermektedir. Analiz, literatürdeki gelişmeleri haritalayarak bilgi boşluklarını ve yeterince çalışılmamış alanları ortaya koymaktadır. Veriler, karbon ayak izi çalışmalarının ağırlıklı olarak çevre mühendisliği ve sürdürülebilir kalkınma alanlarında yoğunlaştığını, sosyal bilimlerde ise eksik kaldığını göstermektedir. Yayınların çoğu ABD, Çin ve Almanya kaynaklı olup, gelişmekte olan ülkelerde araştırma kapasitesinin güçlendirilmesi gerekliliğini vurgulamaktadır. "Sürdürülebilirlik", "yenilenebilir enerji" ve "sera gazı emisyonu" en sık kullanılan anahtar kelimeler olarak öne çıkmakta; artan atıf oranları alandaki akademik çalışmaların derinleştiğini göstermektedir. Çalışma, iklim kriziyle mücadelede bilimsel bilgi ve araştırma odaklarını anlamada stratejik bir temel sunmaktadır.

Anahtar Kelimeler: *İklim Değişikliği, Karbon Ayak İzi, Bibliyometrik Analiz*

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1. INTRODUCTION

Climate change is defined as a complex and multidimensional global problem whose effects have become increasingly tangible and concerning in recent years, capable of profoundly affecting the lives of all living beings worldwide (Kanniah, Zaman, Kaskaoutis & Latif, 2020). The uncontrolled increase in greenhouse gas emissions in the atmosphere creates extensive and long-term effects not only on environmental but also on social, economic, political, and cultural levels. Physical changes such as the faster-than-expected rise in global average temperatures, the alarming rate of melting glaciers in polar regions, and the dangerous rise in global sea levels are becoming more pronounced and concerning with each passing year (IPCC, 2019). These processes pose serious and urgent threats, especially to people living in coastal areas and low-altitude regions; both the frequency and destructive impact of natural disasters such as seawater floods, severe storms, sudden and intense rainfall, floods, and water overflows are increasing notably (UNFCCC, 2022). Climate change, along with disasters such as landslides, desertification, and prolonged drought, is causing critical depletion of underground and surface water resources, serious disruption of agricultural production and food supply chains, and irreversible damage to sensitive ecosystems (FAO, 2020). This concerning situation could reach a critical level in the near future, potentially leading to global food crises that could directly threaten the nutrition and food security of millions of people worldwide and destabilize social and economic stability (Graham, 2022).

Climate change is at the center of the international agenda as one of the most important environmental, social, and economic issues of the 21st century. This phenomenon, which poses a global threat with effects such as rising temperatures, extreme weather events, and sea level rise, has become a crisis that requires humanity to produce urgent solutions. In this context, the concept of carbon footprint has become a strategic tool that allows individuals, institutions, and countries to measure and evaluate their impact on the climate (Wiedmann & Minx, 2008)

Carbon footprint is an important environmental measurement that represents the total amount of greenhouse gases or carbon dioxide emissions released into the atmosphere throughout a product or activity's life cycle. This measurement is currently recognized as one of the fundamental indicators in sustainability studies (Wiedmann & Minx, 2008). In other words, carbon footprint is a comprehensive concept that measures and evaluates the environmental damage caused by human activities (transportation, heating, electricity use, consumed products, etc.) in terms of greenhouse gas emissions, as units of carbon dioxide. This concept enables the concrete measurement and comparison of environmental impacts at both individual and institutional levels. By analyzing 3,459 articles in Web of Science between 2000-2022, the areas where carbon

footprint research is concentrated, production differences between countries, and study themes have been successfully revealed (Ellouz & Barkouti, 2023).

Scientific research has established that carbon emissions from human activities have serious and permanent negative effects on the world's ecosystem. These emissions, which underlie problems such as global warming, climate change, and biodiversity loss, threaten the ecosystem's balance. In this regard, organization employees, suppliers, civil society organizations, and politicians play an important role in the process of reducing carbon emissions (Penz & Polsa, 2018). Each of these stakeholders can contribute to change by promoting sustainable practices and supporting carbon reduction strategies in their spheres of influence. Additionally, it has been emphasized that efforts to raise public awareness and consciousness are of great importance in this matter (Galli, Wiedmann, Ercin, Knoblauch, Ewing, & Giljum, 2012). These efforts provide motivation for individuals to make more sustainable choices in their daily lives and reduce their carbon footprints. To prevent these negative outcomes or at least mitigate their effects, it is of great importance to develop and implement comprehensive and effective adaptation policies against climate change. For these policies to succeed, both short term and long-term goals need to be established and systematically monitored. The sustainability of natural resources and protection of ecosystems should constitute the fundamental aim of such policies and should be among the indispensable priorities for leaving a livable world for future generations (IPCC, 2019). In particular, reducing greenhouse gas emissions is one of the most important and urgent steps to slow down climate change and minimize the negative effects of global warming. Controlling greenhouse gas emissions is vital to reduce the impacts of climate change on ecosystems, human health, and economic systems. In this context, controlling emissions from industrial facilities, increasing energy efficiency, adopting innovative technologies, and transitioning to sustainable production methods are of critical importance. Comprehensive strategies for reducing carbon emissions encompass many different areas, such as expanding the use of renewable sources like solar, wind, and geothermal in energy production, implementing more environmentally friendly alternatives in transportation like public transit and electric vehicles, effectively protecting existing forests and creating new forest areas, promoting sustainable agricultural practices that protect soil and water resources, and optimizing industrial processes to minimize environmental impacts. The successful implementation of these strategies at local, national, and global scales plays a decisive role in reducing the effects of climate change and building a sustainable future. The effective implementation of these strategies is critical to achieving long-term environmental goals. This requires establishing strong cooperation and coordination among governments, the private sector, civil society organizations, and citizens, as well as developing the necessary financial resources and technological infrastructure. This multi-stakeholder approach will enable the production of holistic and effective solutions in achieving sustainable development goals and combating climate change.

In recent years, the topic of carbon footprint has become an area of intense interest among researchers both nationally and internationally, taking center stage in sustainable development and environmental protection efforts. Particularly as the global effects of climate change become more evident, the number and scope of academic studies on this subject have increased significantly. This research aims to provide a comprehensive and systematic bibliometric overview of past and current trends in articles on carbon footprint and climate change indexed in Web of Science (WOS) and Scopus databases, leading platforms of global academic literature.

The increasingly visible global effects of climate change have led to a significant increase in academic studies in this field. This research aims to quantitatively identify current gaps in the literature and research growth by examining trends from past to present in publications on carbon footprint and climate change in databases such as Web of Science (WOS) and Scopus using bibliometric methods. The analysis conducted within this scope makes a major contribution to understanding the direction of scientific knowledge in combating the climate crisis. It also aims to

reveal the knowledge structure and transformations over time by evaluating scientific publications on carbon footprint and climate change through bibliometric analysis. This analysis provides the opportunity to map past academic contributions as well as identify under addressed themes, potential collaborations, and data based orientations for policymakers. We can list the projections in scientific production of interdisciplinary intersections related to carbon footprints for example, in areas such as urban planning, supply chain management, agriculture among the unexplored areas this study highlights. It not only maps the historical development and current dynamics of academic literature but also provides a data-based roadmap for future sustainability policies, technological investments, and interdisciplinary collaborations. Carbon footprint research inherently has a multi-stakeholder structure. Universities and research institutions assume pioneering roles in developing theoretical approaches and standardizing measurement methods. The private sector contributes to the process with applied data production and innovative solution models, especially in high-emission sectors such as energy, transportation, and food. However, the effectiveness of these strategies is directly related to policies suitable for global cooperation, support from local governments, and social awareness (Kaman & Bozkurt, 2025). Additionally, governments and policymakers integrate scientific outputs into climate policies, feeding mechanisms such as carbon pricing, carbon tax, and emission trading systems from these researches (Setiawan et al., 2023). This interaction demonstrates that academic knowledge production finds concrete responses not only at the scientific level but also at the social and economic level.

Bibliometric analyses on climate change and carbon footprint reveal that academic production in this field has increased significantly both quantitatively and qualitatively over the years (Marvin & Augustine, 2025). It has been noted that there was a significant increase in carbon-related publications between 2010-2025, with China and the UK being at the forefront of carbon neutrality research (Setiawan et al., 2023). In a bibliometric analysis on climate change and accounting research, a substantial increase in publication volume during the 2013-2023 period was highlighted, emphasizing that this increase was linked to global events and institutional orientations (Lindawati & Meiryani, 2024). Analyses covering the years 2006-2022 identified an increasing trend toward applied themes such as energy efficiency and carbon management (Dong et al., 2024). Research clusters identified through social network analyses in carbon footprint publications during the 2007-2022 period were presented, highlighting developments in sustainability assessments and calculation methods (Zhao et al., 2023). International carbon emissions literature was examined using scientific knowledge mapping methods; hot topics that could be effective in policy-making processes were identified (Han et al., 2022). Emphasizing the importance of input-output analyses in carbon footprint research, a two-stage development process focusing particularly on supply chain and impact factors was determined (Zheng, Li & Chai, 2023). Finally, a study covering the period 1991-2022 examined the development of carbon peak and carbon neutrality research, systematically revealing growth dynamics in the literature (Ellouz & Barkouti, 2023). Using Web of Science (WOS) data, carbon footprint and climate change research trends were analyzed for the 2000-2022 period (3,459 articles), showing that the USA, China, UK, Australia, and Germany accounted for 60% of total production (Fu & Waltman, 2021). A large-scale study based on bibliometric analysis of approximately 120,000 climate change publications between 2001-2018 was presented, detailing how research areas shifted from physical sciences to policy models and examining production differences between countries in detail (Ketrez, 2024). A bibliometric and visual analysis covering carbon emissions, carbon footprint, carbon tax, and green technology diffusion topics was conducted for the years 2015-2024. Additionally, the development of the field was examined through visual bibliometric mapping of carbon footprints based on 626 articles in a healthcare sector-based analysis. Despite these example studies being conducted within the framework of a single topic or sector, they emphasize that this study is the first more comprehensive work that covers both ‘‘climate change’’ and ‘‘carbon footprint’’ concepts, encompasses the 2010-2025 period, and is based on two major international databases.

While these studies reveal that bibliometric methods are effectively used in the field of climate change and carbon footprint, they show that research focusing on the 2010-2025 period that addresses these themes simultaneously and holistically is limited. In this respect, the current study aims to fill a significant gap in the literature by presenting a large-scale analysis that covers both fields and jointly uses Scopus and Web of Science databases.

1.1. Development Processes of Carbon Footprint and Climate Change Research Early Periods (19th Century - Early 20th Century)

Climate change and carbon footprint topics are closely related to the characteristic properties of various gases in the atmosphere and their complex interactions on Earth's surface, rather than being merely a subject of scientific curiosity. Towards the end of the 19th century, the establishment of temperature data was of great importance in understanding global warming. Research shows that temperatures were approximately 0.20°C colder compared to the average temperature values of the 20th century (Schneider et al., 2023). The instrumental observations and measurements conducted during this historical period, particularly the records kept by the East India Company, emerged as extremely important data sources for determining and examining atmospheric and temperature changes following large-scale volcanic eruptions (Brohan et al., 2012). These observations and measurements have made significant contributions to the development of modern climate science by establishing a fundamental reference point in understanding the natural variability of the climate system and evaluating the effects of various atmospheric events on global climate.

19th in the period extending from the end of the century to the beginning of the 20th century, climate change and carbon footprint research reflect an important era where the impact of human activities on climate gained increasing recognition and scientific studies accelerated. Two significant discoveries formed the theoretical foundation of modern climate science: John Tyndall's identification of the greenhouse effect by discovering the ability of atmospheric gases to trap solar radiation (1859) and Swedish chemist Svante Arrhenius's demonstration through mathematical models that increased CO_2 concentration in the atmosphere could cause significant rises in global temperatures (1896) (Fleming, 1998). During this period, with the acceleration of industrialization, the potential effects of industrial emissions from coal-fueled factories and transportation vehicles on the climate system began to be noticed and discussed by scientists (Haszpra, 2022). Historical life cycle analyses and archival studies conducted in Denmark chronologically documented changes in carbon footprint during the process of social development (Bruhn et al., 2024). The human-induced (anthropogenic) global warming theories of Arrhenius and later Guy Stewart Callendar initially received limited interest. Over time, these theories created increasing interest and research motivation in the scientific community (Weart, 2015). However, due to the complex structure of the climate system, the multiplicity of variables, and limitations in measurement methods, scientific skepticism and alternative views continued to exist in academic discussions for a long time (Lobus et al., 2023).

1.2. Mid to Late 20th Century

In the mid-century, the effect of greenhouse gases on global temperatures became increasingly evident through scientific research and observations. Comprehensive studies during the period known as Early Twentieth Century Warming (ETCW) clearly demonstrated that the effect of greenhouse gases in the atmosphere led to significant temperature increases as a result of complex interactions between both natural climate variability and anthropogenic factors. Furthermore, during this critical period, severe climate anomalies such as the Dust Bowl that affected large agricultural areas in North America during the 1930s and 1940s dramatically demonstrated the profound and lasting effects of human activities on climate systems (Hegerl et al., 2018). Such

large-scale environmental events served as an important catalyst in developing social awareness about climate change and laid the groundwork for the strong emergence of scientific and political discussions about human induced climate variability. These developments have established a solid foundation for the multi-factor analysis approach of today's climate modeling methods.

1.3. 1980s-2000s: Foundation of Carbon Footprint and Climate Change Research

In the 1980s, the concept of carbon footprint began to gain significant prominence in scientific literature through comprehensive research and studies aimed at measuring the impact of individual and social consumption on greenhouse gas emissions. This concept marks a turning point in terms of quantitative assessment of environmental impacts and setting sustainability goals. Particularly in the 1970s, a notable peak in attention to carbon footprint was observed, significantly increasing academic and political interest in consumption-based emission calculations. Researchers and policymakers began to examine the environmental impacts of individual consumption patterns in more detail. In the late 1980s, the United Nations Intergovernmental Panel on Climate Change (IPCC) was established, and this important development played a critical role in forming the first international consensus on the effects of global warming. During this period, the scientific consensus that climate change was human-induced grew stronger and was supported by research results from various disciplines. The carbon footprint concept began to be widely used, especially in the 1990s, as a systematic way to measure, monitor, and evaluate greenhouse gas emissions released into the atmosphere by individuals, institutions, and organizations. This methodological approach has become a fundamental tool in identifying and developing reduction strategies for emission sources at different scales. During this period, debates between technological optimism and pessimism regarding climate change mitigation came to the forefront intensively in academic and political circles, with detailed emphasis on the technical, economic, and social complexities of addressing emissions in different consumption sectors (Bruhn et al., 2024). These multidimensional discussions clearly demonstrated the urgent need for more comprehensive, systematic, and integrated strategies in combating climate change and formed the foundation of today's sustainability policies.

1.4. 21st Century: Fighting Carbon Footprint and Global Climate Change

In this century, especially with the Paris Climate Agreement (2015), the fight against climate change gained even more importance on a global scale. Carbon footprint has become a fundamental tool in assessing the environmental impacts of not only countries but also companies, individuals, and industries. Research has focused on methods to limit greenhouse gas emissions by examining the environmental, economic, and social dimensions of carbon footprint reduction targets. Current research emphasizes that more comprehensive strategies are needed to reduce greenhouse gas emissions by combining knowledge gained from past periods with modern technological advances. However, as evidenced by fluctuating carbon footprints over decades, balancing economic prosperity with environmental sustainability remains a fundamental challenge (Bruhn et al., 2024). Although significant progress has been made in understanding climate change, reconciling economic growth with environmental sustainability remains a major challenge. The historical course of carbon emissions and climate variability continues to shape today's strategies for combating climate change. The success of these strategies depends on establishing a healthy balance between reducing greenhouse gas emissions and economic development.

This historical continuity plays a decisive role not only in understanding the past in climate change research, but also in developing future policy, technology, and society-based solutions. Contemporary research, as part of a line extending from Arrhenius's (1896) theoretical calculations to the IPCC's scenarios, examines humanity's impacts on the environment and seeks common responses to these impacts. This process, which follows historical trends, clearly

demonstrates both the continuity of scientific studies and how these studies shape current practices (Arrhenius, 1896). This situation reveals that the fight against climate change is not just a current issue, but also relies on knowledge accumulated from the past and long term strategies. Carbon footprint and climate change research have over time become influential not only in scientific circles but also in policy development processes. These scientific efforts continue to guide both theoretical and applied fields in line with sustainable development goals.

2. MATERIALS AND METHODS

The primary material of this research consists of international academic studies and relevant literature articles on climate change and carbon footprint. In January 2025, academic studies published between 2010-2025 in the Web of Science (WOS) database were examined in detail. The selection of the 2010-2025 time span was made to provide an up-to-date and comprehensive overview of the literature on carbon footprint and climate change research. Identifying 2011 as the starting year is associated with the period marking significant growth and institutionalization in global climate change research. In particular, the increasing influence of international climate policy frameworks and the wider adoption of bibliometric studies in this field have made this period critical. Moreover, this time span enables a systematic analysis of recent developments, emerging research trends, and policy-oriented academic outputs, thereby strengthening the conceptual coherence and temporal relevance of the dataset. In the literature review, the keywords "climate change" and "carbon footprint" were used as search strings. In addition, to broaden the scope of the search strategy, related supplementary keywords such as "CO_2 emissions," "carbon emissions," and "greenhouse gas emissions" were incorporated into the query structure. The exact query strings used in the study were as follows: [("climate change" OR "CO_2 emissions" OR "carbon emissions" OR "greenhouse gas emissions") AND ("carbon footprint" OR "carbon footprint" OR "carbon foot print")], and this query was searched within the title, abstract, and keyword fields. As inclusion criteria, academic journal articles and conference proceedings published in English between 2010 and 2025 were selected. The exclusion criteria were defined as publications that did not contain the relevant keywords, studies for which the full text was not accessible, and duplicate (redundant) records (Donthu et al., 2021). In the analysis process, basic bibliometric indicators such as number of publications, citation count, h-index, number of authors, co-authorship relationships, keyword co-occurrence, and citation effects were used. These indicators enabled multifaceted analysis of dimensions such as academic production rates, institutional and national collaborations, author networks, and subject representation in specific regions. The primary material of this research consists of international academic studies and relevant literature articles on climate change and carbon footprint. Research on climate change and carbon footprint has increased significantly over the last twenty years. However, there is still a lack of systematic bibliometric analysis regarding the scientific production dynamics of these studies. In January 2025, studies published between 2010-2025 were comprehensively analyzed using Web of Science (WoS) and Scopus databases. This analysis aims to reveal publication trends, research collaborations, and the transformation of thematic focuses. As the impacts of climate change become increasingly urgent, this gap in the literature has made understanding research orientations a strategic necessity (Kaya & Uzun, 2024). Our study aims to support the decision-making processes of policymakers, academics, and private sector actors in a data driven manner.

Emphasized that bibliometric analyses include main and enriched techniques. Performance analyses and science maps are among the main techniques, while network analyses are included in enriched techniques. All of these techniques were utilized in this research. In the first phase of the bibliometric analysis method, research in Scopus and WoS databases related to carbon footprint and climate change was examined. Subsequently, the most productive authors, research years, topic development rates, countries, prominent keywords, relationships between words,

and popularity periods of concepts were addressed. Analyses were conducted through comparison of Scopus and WoS databases. This approach is expected to bring different perspectives to the literature. The Web of Science (WOS) database was found suitable to meet the research requirements (Kaya & Uzun, 2024). The analysis results cover publications between 2010-2025 in both WoS and Scopus databases. The research seeks answers to problems related to the following variables:

2.1. Research Questions Under Thematic Categories

2.1.1. Productivity Trends

- What are the Year, Number of Research, Annual Growth Rate (%), Total Citation Count, Total Citation Count (Excluding Self-citations), Average Citation Count, and H-Index ratios of carbon footprint and climate change research in Scopus and WoS databases?

2.1.2. Collaboration Networks and Prominent Actors

- Who are the main authors, countries, and what are the keywords in carbon footprint and climate change research?

2.1.3. Keyword Dynamics

- In which years did the most frequently emphasized keywords and research intensity increase in carbon footprint and climate change research?
- What is the structure of keyword relationships and co-occurrence network in carbon footprint and climate change research?

2.1.4. Thematic Maps and Conceptual Development

- Which concepts stand out in the thematic map of carbon footprint and climate change research?
- How have the development processes of carbon footprint and climate change research been shaped?

2.1.5. Political and Scientific Implications

- What are the findings from carbon footprint and climate change research and what measures should be taken for the future?

The density maps created within the scope of the study were prepared using the VOSviewer program to visualize the distribution of research topics over time. Keyword co-frequency density mapping was used to determine thematic density centers. Bibliyometric mapping and network visualization analyses were conducted using VOSviewer software (version 1.6.20). To improve analytical robustness and reduce noise in the dataset, a minimum occurrence threshold for documents/keywords was applied, and only items meeting the predefined frequency criterion were included in the analysis. For constructing network structures, the “association strength” normalization method commonly used in bibliometric co-occurrence analyses was preferred (van Eck & Waltman, 2010). Clustering was performed using VOSviewer’s built-in modularity-based clustering algorithm; the resolution and minimum cluster size parameters were optimized in accordance with standard methodological approaches used for large-scale bibliometric datasets. These parameter settings contributed to clearer identification of thematic structures and improved interpretability of the network maps. In addition, CiteSpace was used only as a reference within the theoretical framework of the study and was not included in the empirical analysis process. All bibliometric analyses in the study including co-authorship, keyword co-occurrence, and visualization of citation networks were carried out solely using VOSviewer. VOSviewer was selected because it can efficiently perform network-based analyses on large-scale bibliometric datasets and

visualize results with a high level of interpretability (Cobo et al., 2011). This approach is consistent with the methodological framework widely adopted in the bibliometric analysis literature.

This visualization technique enables the analysis of knowledge clusters in the research field by revealing prominent topics in literature and interdisciplinary transitions (Van Eck & Waltman, 2010). In the climate change literature of education, country and institution-based collaborations and the most frequently used keywords (for example ''climate change'' and ''sustainability'') have been presented with formal maps (Dönmez & Doğan, 2023). ''Hot themes'' and author collaborations in the international carbon emissions literature have been analyzed using VOSviewer through scientific knowledge mapping methods. As a result of these analyses, both author networks and thematic clusters at the country level have been clearly revealed (Zhao et al., 2023). In a study published by MDPI, VOSviewer and CiteSpace were used together to perform ''co-citation,'' ''dual-map overlay'' and ''keyword co-occurrence networks'' analyses. Through this, the knowledge structure of the literature and leading trends have been systematically mapped.

3. RESEARCH FINDINGS

3.1. Publication Metrics

With the help of bibliometric analyses, research from Web of Science (WoS) and Scopus, which are among the most important databases of academic publications, were thoroughly searched to comprehensively examine the topics of carbon footprint and climate change in the literature, and the findings obtained are systematically summarized in Table 1. These databases were selected considering both the breadth of publications they cover and the quality standards of academic studies.

Table 1. General results of carbon footprint and climate change research

Data	Year	Number of Research	Annual Growth Rate (%)	Total Number of Citations	Total Number of Citations (Excluding Self-citations)	Total Number of Citations (Excluding Self-citations)	H-Index
WoS	2010-2025	111	%1.698	125,983	122,017	178,266	27.27
Scopus	2010-2025	195	%23,45	2,000	1,800	58,65	18,08

This table compares the bibliometric characteristics of research on ''carbon footprint'' and ''climate change'' between Web of Science (WoS) 2011-2025 and Scopus 2010-2025. In the Web of Science (WoS) database, a total of 111 articles have been published with an annual growth rate of 1.698%. These studies received 125,983 total citations, with 122,017 citations excluding self-citations. The average citation count and H-Index value were determined to be 27.27. This data indicates that research published in WoS has high academic impact. In the Scopus database, 195 studies have been published, and the annual growth rate has reached 23.45%. Research in Scopus received 2,000 total citations, with 1,800 citations excluding self-citations. The average citation count is around 58,65 and the H-Index value is 18.08. This situation demonstrates that research published in Scopus shows rapid growth and reveals increasing academic interest in the subject. Citation counts and H-Index values in both databases indicate growing academic impact in the field. While WoS research reaches a broader academic audience, the high growth rate in Scopus indicates that this field is rapidly spreading as a new research topic. This analysis proves that carbon footprint and climate change topics are receiving increasing attention in scientific circles. As shown in Figure 1 and Figure 2, when examining the distribution of articles by year, the highest number of articles was reached in 2024.

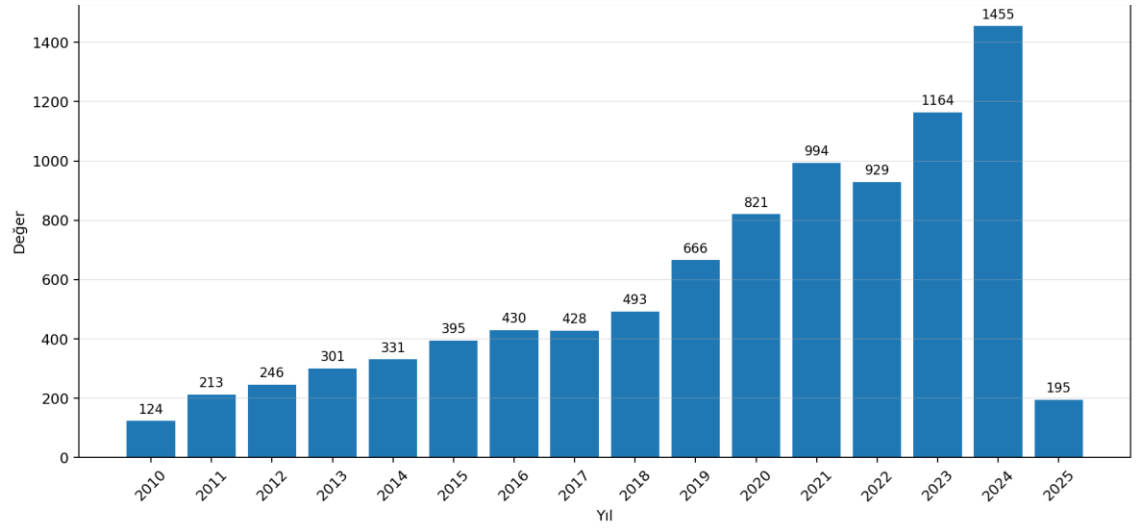


Figure 1. Distribution of Articles by Years (Scopus Data)

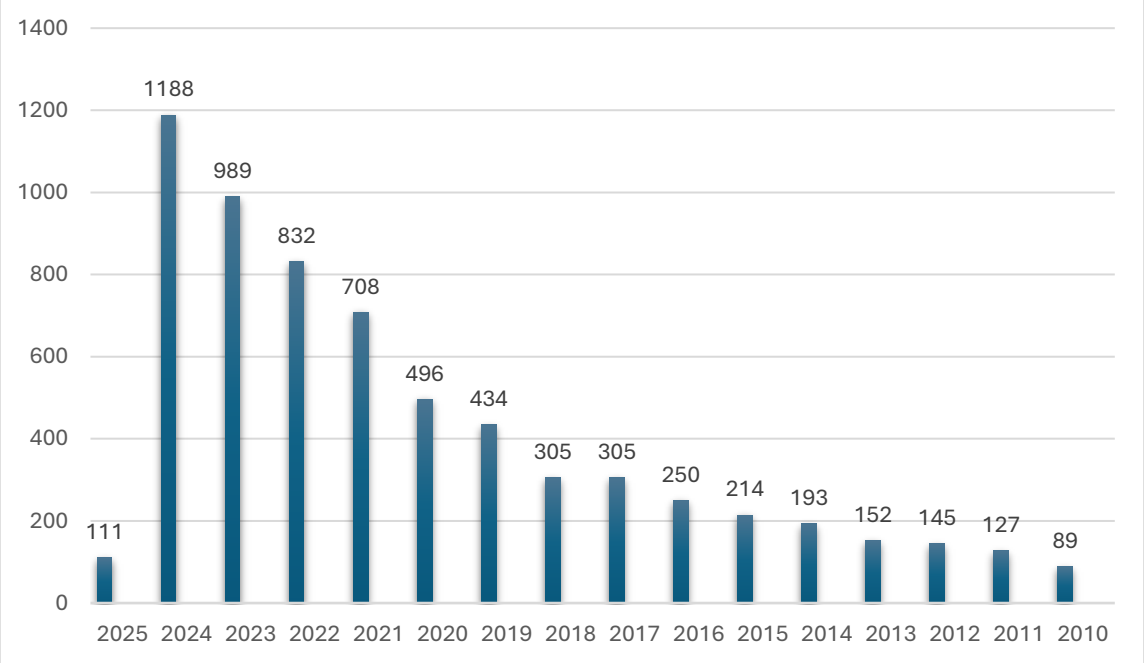


Figure 2. Distribution of Articles by Years (WoS Data)

Web of Science (WoS) and Scopus databases are two distinct citation indexing systems that hold significant importance in academic literature. According to data up to 2025, annual publication numbers have shown continuous growth in both databases. While WoS published 1,188 documents in 2024, 989 in 2023, and 832 in 2022, Scopus contains 1,455, 1,164 and 929 documents respectively for the same years. This data demonstrates that Scopus indexes more academic publications. When examining 2020 and earlier, a similar trend is observed: in 2020, WoS had 496 documents while Scopus had 821 documents; in 2015, WoS had 214 documents while Scopus had 395 documents. These differences stem from the databases' varying scope, indexing criteria, and content strategies across disciplines.

3.2. Author Contributions

While Scopus can be said to have broader coverage compared to WoS, both databases are considered reliable sources in academic studies and are widely used in citation analyses. The number of publications in Scopus for authors shown in Figure 3 are as follows: Tollefson, J. (29 publications); Haines, A. and Heinonen, J. (25 publications each); Smith, P. (23 publications); Ebi, K.L. and Styles, D. (21 publications each); Junnila, S. (18 publications); Hertwich, E.G. and McGain, F. (17 publications each); Lenzen, M. and Ottelin, J. (16 publications each); Feijoo, G. (15 publications); Carvalho, M., González-García, S. and Wiedmann, T. (14 publications each); Azapagic, A. and Nilsson, M. (13 publications each). These authors have made significant contributions in the fields of sustainability, climate change, health, and environmental sciences.

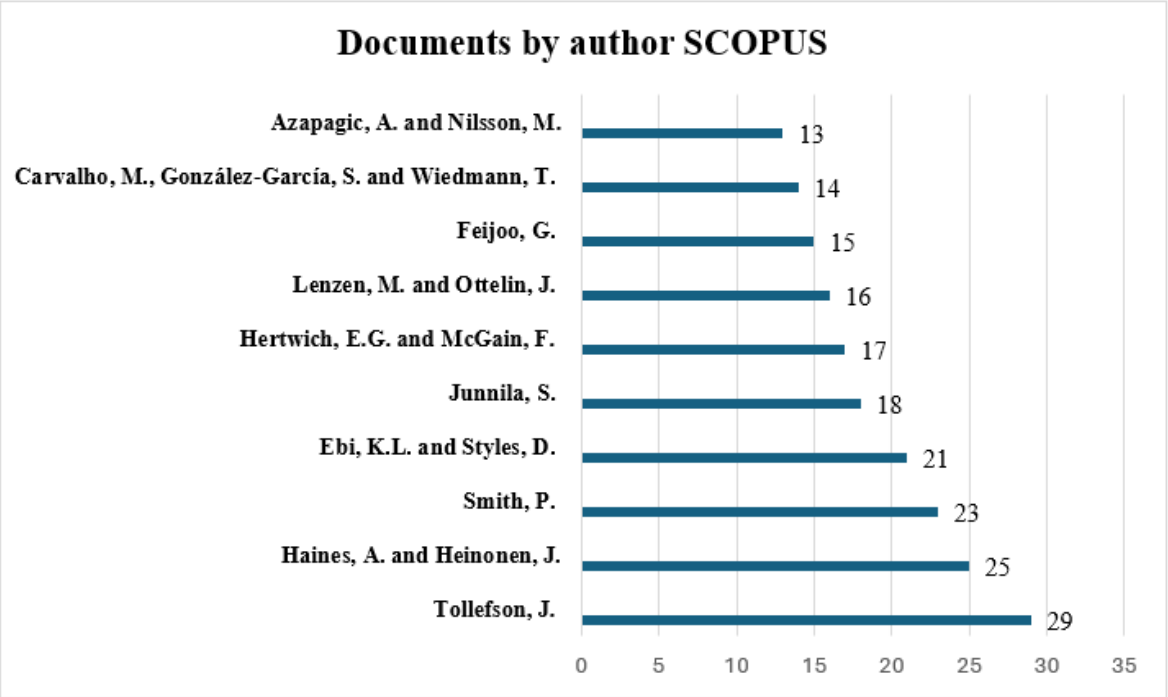


Figure 3. Distribution of Articles by Authors (Scopus Data)

Figure 4 shows the names and citation percentages of the most cited authors in academic studies. The authors' surnames are listed alphabetically, with citation counts and total citation percentages indicated next to each name. For example, while ''Ahmad S'' has 21 citations with a ratio of 0.316%, ''Fuluana-i-palmer P'' and ""Heinonen J'' have achieved the highest citation rates with 26 citations. The prominent academics mainly work in the fields of environmental science, sustainability, and life cycle analysis. The abundance of authors with the same surname but different initials in the list indicates that some surnames are common in the academic community. The higher citation counts of some authors demonstrate that they have conducted influential research in their fields. The citation rates show that the scientific contributions of these names are widely recognized.

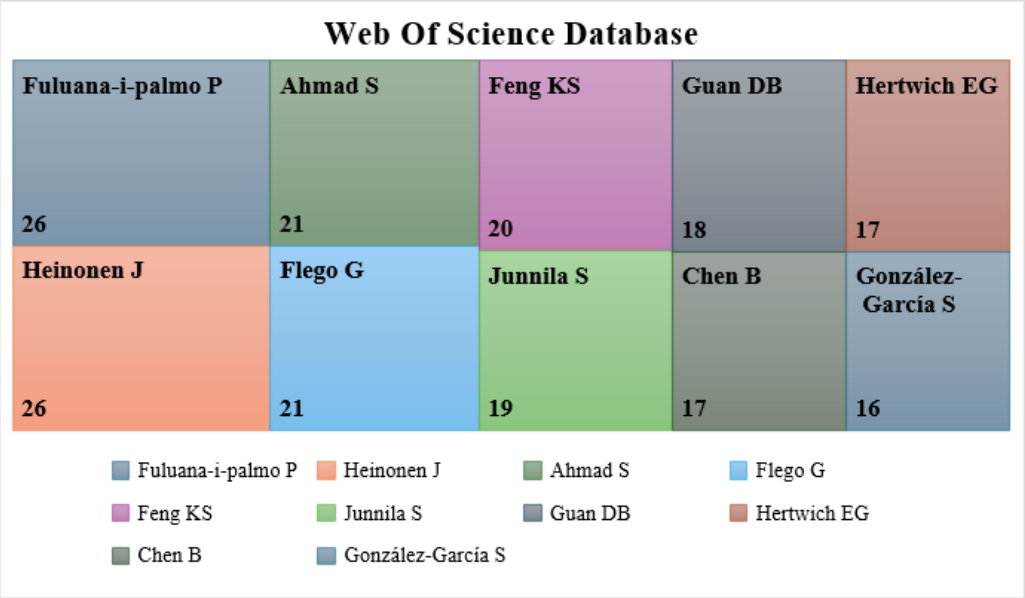


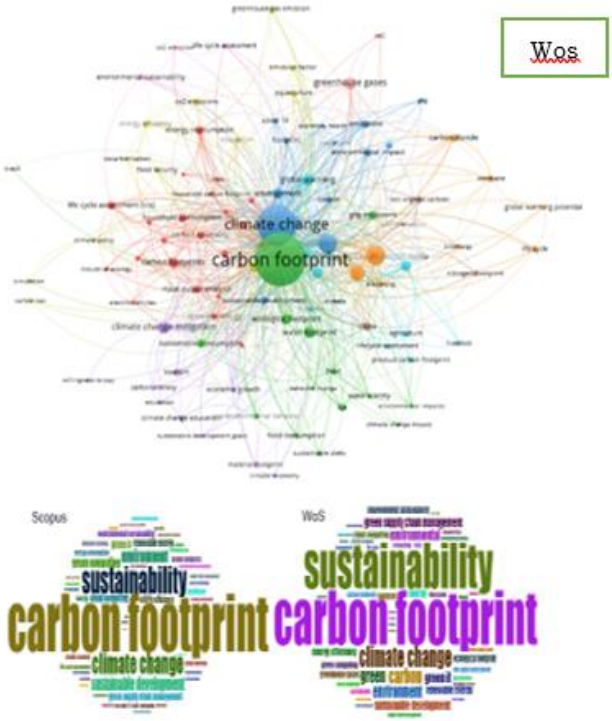
Figure 4. Detailed Distribution Analysis of Research on Carbon Footprint and Climate Change by Authors (Data Obtained from Web of Science Database)

Table 2. Comprehensive Country-Based Comparison of Academic Studies in Carbon Footprint and Climate Change Fields: Detailed Analysis of Publication Statistics Obtained from Web of Science and Scopus Databases

Country	WoS Publications	Scopus Publications
United States	1,354	2,081
People's Republic of China	1,107	1,216
United Kingdom	753	1,355
Germany	533	623
Australia	502	678
Spain	448	467
Canada	401	515

As shown in Table 2, the total numbers and percentage distributions of academic publications on carbon footprint and climate change in Web of Science (WoS) and Scopus databases have been compared. The USA has the highest number of publications in both databases, followed by the United Kingdom and China respectively. The high publication rates of the USA and the UK demonstrate these countries' leading positions in climate change research. The relatively low number of studies from developing economies such as China and India indicates the development potential of academic productivity and future research opportunities in these countries.

3.3. Keyword Analysis



Category	Scopus Featured Terms	WoS (Web of Science) Featured Terms
Environmental Themes	carbon footprint, climate change, GHG	carbon footprint, climate change, environment
Sustainability	sustainability, sustainable development	sustainability, green, sustainable consumption
Energy & Efficiency	energy use, CO2 emissions	energy efficiency, emissions reduction
Management and Strategy	-----	carbon management, green supply chain management

Figure 5. The most prominent keywords in research related to the subject

As shown in Figure 5, the keywords that authors focused on most in the Scopus database research are: carbon footprint, sustainability, climate change, environment, sustainable development, green computing, greening, cloud computing, green supply chain management, renewable energy, energy efficiency, environmental sustainability, carbon footprints, energy, energy consumption, healthcare, circular economy, CO2 emissions, and global warming. In the WoS database research, the keywords most emphasized by authors are: carbon footprint, sustainability, climate change, carbon, green, environment, greening, green supply chain management, sustainable development, energy, energy efficiency, renewable energy, cloud computing, ecological footprint, greenhouse gases, environmental sustainability, footprint, life cycle assessment, and carbon footprints.

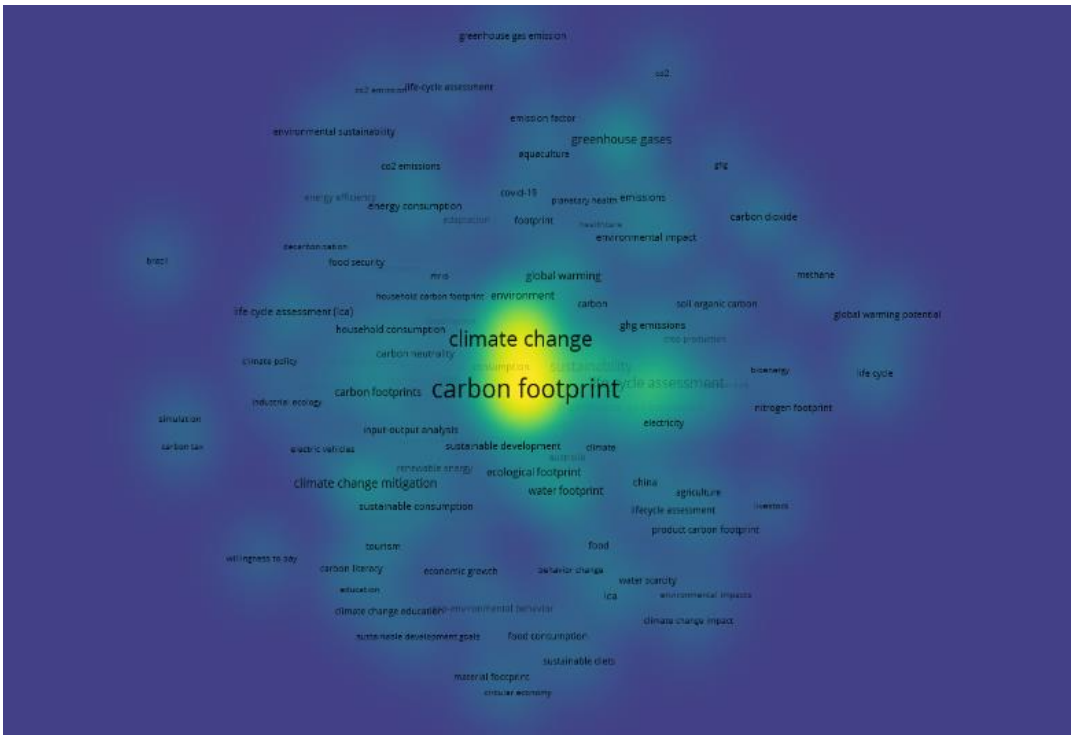


Figure 6. Density Map of Climate Change and Carbon Footprint Concepts in Scientific Literature

As shown in Figure 6, This visualization represents a comprehensive density map created using VOSviewer, an advanced visualization software. The map shows the frequency and density of usage of ‘‘Climate Change’’ and ‘‘Carbon Footprint’’ concepts, which are among today’s most important environmental issues, in academic and scientific literature.

Yellow and Green Regions: The yellow and green areas on the map represent the most frequently used terms. These colored regions visually demonstrate the most cited and discussed concepts in academic studies and scientific research. ‘‘Carbon Footprint’’ and ‘‘Climate Change’’ stand out as the most frequently referenced terms in scientific literature. These two concepts are directly linked to fundamental issues such as global warming, environmental impact, and sustainability, possessing an extensive literature network. Additionally, these concepts are central to environmental research, establishing strong connections with other related topics. This density indicates that scientific communities closely associate these two terms and that the search for global solutions to climate change is shaped around these two fundamental elements. This visual representation also clearly reveals the priority focus areas of academic research and policy development processes.

Blue and Green Regions: Blue and green areas indicate terms used with medium frequency. Terms particularly prominent in these regions, such as ‘‘Greenhouse Gases,’’ ‘‘Global Warming’’ and ‘‘Sustainability’’ represent secondary concepts frequently encountered in topics related to climate change and carbon footprint. These terms shape discussions in various aspects of climate change literature and provide a solid foundation for developing multidisciplinary solution proposals. In climate science studies, greenhouse gas emissions and global warming issues emerge as central topics examined in both theoretical research and applied studies. The medium-frequency usage of these concepts indicates that the subject is addressed at a level that appeals to both technical and general readership.

Dark Blue Regions: Dark blue areas represent less common or specialized subtopics in research literature that require specific expertise. ‘‘Carbon Tax,’’ ‘‘Water Scarcity’’ and ‘‘Life Cycle Assessment’’ can be cited as examples of these areas. These specific terms indicate specialized fields of study that require research and analysis in sustainability and environmental issues. While

carbon tax and water scarcity issues are at the intersection of economic incentives and environmental policy proposals in combating climate change, these areas also constitute important components of social and industrial transformation. On the other hand, life cycle assessment represents a comprehensive and technical methodological approach used in systematically measuring environmental sustainability and calculating the carbon footprint of a product or service from production to disposal. This analysis clearly shows that climate change and carbon footprint topics are addressed from different perspectives and at varying levels of depth in the two data sources examined.

4. DISCUSSION AND CONCLUSION

Data on the evolution and current status of carbon footprint and climate change research shows that these topics are receiving increasing attention in the scientific community. The comparison of research in Web of Science (WoS) and Scopus databases clearly demonstrates the scope of both topics in academic literature. The high citation counts and H-Index values in the WoS database indicate that these studies have created a broad academic impact. Moreover, the higher annual growth rate of research in Scopus proves that academic interest in climate change and carbon footprint issues is rapidly increasing (Bruhn et al., 2024).

Looking at annual growth and differences between countries, the disparity between annual growth rates in the two databases reveals significant findings. While databases like WoS that started earlier have a more solid academic foundation, Scopus has shown rapid growth by covering more publications in certain years. A rapid increase has been observed in both databases particularly after the 2020s. Furthermore, the differences between countries are noteworthy. The high publication numbers of the USA and United Kingdom in both databases reinforce these countries' leadership roles in climate change research. The relatively low publication numbers in developing economies like China and India present opportunities for these countries to increase their future research potential and academic productivity (Brohan et al., 2012). Looking at Key Terms and Research Trends, the keywords in climate change and carbon footprint research reflect the trends in literature. Basic concepts like ''Carbon Footprint'' and ''Climate Change'' are the most frequently used terms in academic literature. Additionally, terms such as ''Greenhouse Gases,'' ''Global Warming,'' and ''Sustainability'' stand out as concepts shaping broader, interdisciplinary solutions to the issue. Low-frequency terms like ''Carbon Tax'' and ''Water Scarcity'' point to more specific areas, and academic interest in these topics will play a more prominent role in future policy development processes (Schneider et al., 2023). In this context, the study by Özyürek (2024), which conducts a bibliometric analysis of thematic areas such as carbon emissions, carbon footprint, carbon tax, and green technology diffusion, contributes to a comprehensive evaluation of research trends in the relevant literature.

Bibliometric analyses in the field of carbon footprint and climate change demonstrate that these topics are being addressed with increasing interest in the academic world. Comparative evaluations conducted through Scopus and Web of Science (WoS) databases reveal both the quantitative and qualitative development of the literature. The WoS database provides a strong academic foundation with high citation numbers and H-index values by establishing a systematic accumulation in earlier periods. In contrast, the high annual publication growth rate detected in Scopus indicates that academic interest in this field has been rapidly rising, especially in recent years (Bruhn et al., 2024). Between 2007-2022, a significant increase was observed in scientific publications in the field of carbon footprint and climate change (Dong et al., 2024). Analyses based on the Scopus database reveal that a total of 343 studies on climate change and sustainable development themes have been identified, and the number of publications peaked in 2021 (Sökmen Gürçam & Gürçam, 2022).

When examining the annual growth rates of the two databases, significant differences in trends over time are observed. While WoS's stability based on continuity ensures long term academic traceability of the subject, Scopus has stood out with higher publication volume especially in the post-2020 period. In this literature, carbon neutrality, sustainability assessments, and carbon accounting methods draw attention as primary research areas. From a methodological perspective, approaches such as life cycle assessment (LCA) and input-output analysis are gaining prominence (Marvin & Augustine, 2025). Research trends show a shift from scientific understanding of climate systems toward technological solutions for climate change mitigation and the development of regulatory policies (Lindawati & Meiryani, 2024). When examining geographical distribution, China and the United Kingdom stand out as the countries contributing most to the topic of carbon neutrality (Marvin & Augustine, 2025). In contrast, many developing countries, especially regions like Indonesia where local academic output remains limited, have low representation rates in the literature (Rehman et al., 2024). This situation can be associated with sudden policy changes regarding global environmental issues and post-pandemic sustainability emphases. While the USA and United Kingdom maintain leadership in publication distribution by country in both databases, developing countries such as China and India attract attention with their growth potential rather than publication numbers (Brohan et al., 2012). This clearly demonstrates the need to increase research capacity in developing regions. Although the general upward trend in carbon footprint and climate change research is promising, addressing regional research inequalities is an important requirement for the integrity of global scientific efforts in combating climate change.

Keyword analyses play an important role in identifying trends in the literature. While fundamental concepts such as ‘‘Carbon footprint’’ and ‘‘climate change’’ stand out as the most dominant terms in both databases, more strategic and managerial expressions like ‘‘green supply chain’’ and ‘‘carbon management’’ are becoming more prominent in WoS. This indicates that WoS reflects the interdisciplinary approach in the field of sustainability more extensively. On the other hand, terms with low frequency but high political impact, such as ‘‘carbon tax’’ and ‘‘water scarcity,’’ signal that future research agendas will increasingly intersect with public policies and environmental governance (Schneider et al., 2023). In particular, the adoption of the 2015 Paris Agreement is regarded as a critical turning point that triggered both quantitative growth and thematic expansion in the climate change literature (Rogelj et al., 2016). Following this agreement, the adoption of net-zero emission targets and carbon neutrality strategies by countries and institutions has contributed to a marked rise in academic interest in low-carbon transition pathways, sustainable energy systems, and climate adaptation policies (IPCC, 2022; UNEP, 2023). Moreover, the strengthening of international climate governance mechanisms and the broader adoption of policy approaches aligned with the Sustainable Development Goals (SDGs) have supported interdisciplinary research trends that integrate environmental sciences, economics, and public policy (United Nations, 2019). In this context, the bibliometric findings reveal not only an increase in academic output, but also that global climate policies directly shape the scientific research agenda.

In conclusion, carbon footprint and climate change research reflect not only environmental contexts, but also scientific production processes, interdisciplinary collaborations, and countries’ knowledge production capacities. Bibliometric data is a powerful tool for monitoring trends in these areas and determining future research priorities. These analyses serve as an important guide for policymakers, academics, and funders, highlighting emerging themes and regions where research capacity needs to be strengthened.

4.1. Future Measures to Be Taken

4.1.1. Reduction of Carbon Emissions

- The development of effective policies and strategies for reducing carbon emissions is of critical importance. The widespread adoption of renewable energy sources (solar, wind, hydroelectric) offers an important solution in reducing carbon emissions (Wang, 2024).
- Carbon capture and storage technologies (CCS) offer the potential to capture and safely store carbon released into the atmosphere. The widespread and effective use of these technologies plays a major role in achieving long-term climate goals (Widianingsih, 2024).
- Approximately 120,000 climate change publications between 2001-2018 were analyzed, and this study revealed that over time, research has shifted from understanding climate systems to climate technologies and policies. Additionally, the production imbalance between developed and developing countries indicates that policymakers need to empower developing countries (Fu & Waltman, 2021).
- Climate change research encompasses many disciplines including environmental science, meteorology, and ecology, and keywords such as sustainability and climate justice frequently appear in studies (Usta, 2023). There is a notable increase in research on carbon neutrality, with China and the United Kingdom leading in innovation. This research covers technological, policy, and economic dimensions, focusing on renewable energy and carbon capture technologies (Xu et al., 2023).

4.1.2. Sustainable Agriculture and Forest Management

- The agricultural sector is a significant source of the global carbon footprint. This impact can be reduced by adopting sustainable agricultural techniques. Low-carbon farming practices, organic agriculture, and agroecological methods are effective solutions in reducing emissions from agriculture (Sahane et al., 2024).
- Forest conservation and reforestation projects form a key strategy in combating climate change by increasing carbon absorption. Forest ecosystem services are of great importance both in terms of carbon sequestration capacity and biodiversity conservation (Vishvas, 2024).

4.1.3. Policy and Social Awareness

- Strong and globally coordinated policies are necessary to reduce carbon footprint. Carbon tax, carbon trading systems, and green economy policies are effective tools for limiting greenhouse gas emissions and promoting sustainable growth (Khattra et al., 2024).
- Creating awareness about climate change and carbon footprint in society, organizing educational programs and public information campaigns, and encouraging environmentally friendly behaviors are vital. Understanding individual and collective responsibilities by society will increase the effectiveness of policy changes (Adanma & Ogunbiyi, 2024).
- The study ‘‘A bibliometric and topic analysis of climate justice’’ (2024) revealed that the climate justice issue has remained limited to a restricted group of countries and disciplines. The study suggested that groups exposed to impacts in justice-based policies should be identified through comprehensive analyses (Parsons et al., 2024).

4.1.4. Climate Adaptation and Technological Innovation

- Building resilient infrastructure against the negative effects of climate change and implementing risk reduction strategies is necessary. Adaptation measures are particularly important for water resource management, food security, and defense against sea level rise (Cheng, 2024).
- In bibliometric analyses, 222,060 publications between 1980-2014 were examined, and it was observed that adaptation, risk management, and defense topics were less represented in cli-

mate change research compared to other sub-fields. However, a significant increase in these topics was observed after 2005. Research has emphasized that studies particularly on adaptation and vulnerability have high impact values (Haunschild et al., 2016).

- The bibliometric analysis titled "Climate change adaptation policy and governance in the water sector" revealed a 16% annual increase in publications in the field of climate change adaptation and water sector governance during the 2007-2023 period. However, studies in vulnerable regions such as Pacific islands and Sub-Saharan Africa remain insufficient; in line with these findings, the development of priority research programs for water management and climate adaptation in vulnerable regions stands out as a policy recommendation (Majahana et al., 2025).
- Green technology and innovative solutions play a key role in building a sustainable future. Technological innovations provide important tools for improving energy efficiency, enhancing waste management, and reducing carbon footprint. Supporting clean energy and environmentally friendly technologies is essential for achieving sustainable development goals (Alkofahi, Durán, & Saqib, 2024).

Academic research on carbon footprint and climate change has played a key role in systematically addressing global problems by creating significant impact in light of comprehensive scientific data. These studies examine different dimensions of climate change and reveal its effects on both ecological systems and human communities in detail. Research in prestigious databases such as Web of Science and Scopus shows that this field has rapidly expanded in recent years and interdisciplinary studies are increasingly growing. However, strengthening sustainable policies and supporting institutional structures is necessary for research to create deeper and lasting impacts. The transformation of this academic knowledge into practical applications in more areas is critically important, especially in developing countries, for reducing the negative effects of climate change and managing carbon footprint more effectively and sustainably. This transformation process requires coordinated efforts at local and global levels and long term strategic planning.

This study presents a bidirectional and comprehensive analysis covering the period 2010-2025 by using Scopus and Web of Science (WoS) databases together, unlike the existing literature. Unlike studies in the literature that generally focus on a single database, it provides an original contribution in terms of both data diversity and comparative evaluation of global trends. The analyzed time period carries the distinction of being the most current study in the literature by covering publications up to 2025. Keyword distribution maps, author collaboration networks, and country-based production tables created in the study were not only presented graphically, but also clearly labeled, titled, and associated with findings within the text. Each visual has been integrated with the contextual meaning of the analyzed finding and supported with concise yet explanatory comments in the results section. This approach strengthens both the visual readability and the depth and methodological consistency of bibliometric analyses. This holistic approach makes the study not only a contribution to the existing literature but also an exemplary model for bibliometric methodology.

REFERENCES

Adanma, M. U., & Ogunbiyi, E. O. (2024). A comparative review of global environmental policies for promoting sustainable development and economic growth. *International Journal of Applied Research in Social Sciences, 6*(5), 954–977.

Alkofahi, K., Durán, I. A., & Saqib, N. (2024). Net-zero emissions pathways in BRICS economies: The impact of environmental innovations, policy, and human capital on carbon footprint reduction. *International Journal of Energy Economics and Policy, 14*(6), 106–113.

Arrhenius, S. (1896). On the influence of carbonic acid in the air upon the temperature of the ground. *Philosophical Magazine and Journal of Science, 41*(251), 237–276.

Brohan, P., Allan, R., Freeman, E., Wheeler, D., Wilkinson, C., & Williamson, F. (2012). Constraining the temperature history of the past millennium using early instrumental observations. *Climate of the Past, 8*(5), 1551–1563.

Bruhn, S., Gislason, S., Røgild, T., Andreasen, M., Ditlevsen, F., Larsen, J., Sonderholm, N., Fossat, S., & Birkved, M. (2024). Pioneering historical LCA: A perspective on the development of personal carbon footprint 1860–2020 in Denmark. *Sustainable Production and Consumption, 46*, 582–599. https://doi.org/10.1016/j.spc.2024.03.014

Cheng, B. (2024). Research for global carbon emissions influence factor and sustainable reduction science and technology of engineering. *Chemistry and Environmental Protection, 1*(10).

Cobo, M. J., López-Herrera, A. G., Herrera-Viedma, E., & Herrera, F. (2011). Science mapping software tools: Review, analysis, and cooperative study among tools. *Journal of the American Society for Information Science and Technology*.

Dong, Q., Zhong, C., Geng, Y., Dong, F., Chen, W., & Zhang, Y. (2024). A bibliometric review of carbon footprint research. *Carbon Footprint, 1*(1), 1–25. https://doi.org/10.20517/cf.2023.45

Donthu, N. S., Kumar, D., Mukherjee, N., Pandey, N., & Lim, W. M. (2021). How to conduct a bibliometric analysis: An overview and guidelines. *Journal of Business Research, 133*, 285–296. https://doi.org/10.1016/j.jbusres.2021.04.070

Dönmez, İ., & Doğan, G. (2023). Bibliometric analysis of research on the concept of climate change using VOSviewer. *Journal of Educational Research and Reviews, 11*(4), 213–226.

Ellouz, F., & Barkouti, A. (2023). Trends on carbon footprint and climate change research: A bibliometric study from 2000 to 2022. *African Journal of Advanced Pure and Applied Sciences, 2*(1), 71–77. https://doi.org/10.56235/ajapas.v2i1.224

Fleming, J. R. (1998). *The carbon dioxide theory of climate change: Emergence, eclipse, and reemergence (ca. 1850–1950)*.

Food and Agriculture Organization of the United Nations (FAO). (2020). *The impact of climate change on food security*. Retrieved April 6, 2025, from https://openknowledge.fao.org/server/api/core/bitstreams/8629d741-9389-4a56-a536-215209230e3e/content

Fu, H. Z., & Waltman, L. (2021). *A large-scale bibliometric analysis of global climate change research between 2001 and 2018* [Preprint]. arXiv. https://doi.org/10.1007/s10584-022-03324

Galli, A., Wiedmann, T., Ercin, E., Knoblauch, D., Ewing, B., & Giljum, S. (2012). Integrating ecological, carbon and water footprint into a footprint family of indicators: Definition and role in tracking human pressure on the planet. *Ecological Indicators, 16*, 100–112. https://doi.org/10.1016/j.ecolind.2011.06.017

Graham, W. L. (2022). Food security and climate change: Risks and solutions. *Global Food Security Review*.

Han, J., Tan, Z., Chen, M., Zhao, L., Yang, L., & Chen, S. (2022). Carbon Footprint Research Based on Input–Output Model—A Global Scientometric Visualization Analysis. *International Journal of Environmental Research and Public Health, 19*(18), 11343. https://doi.org/10.3390/ijerph19181143

Haszpra, L. (2022). Fejezetek az üvegházhatás-kutatás történetéből: Highlights from the history of greenhouse effect research. *Magyar Tudomány*. https://doi.org/10.1556/2065.183.2022.1.5

Haunschild, R., Bornmann, L., & Marx, W. (2016). Climate change research in view of bibliometrics. *Scientometrics, 109*(2), 1–29. https://doi.org/10.1007/s11192-016-2039-3

Hegerl, G. C., Brönnimann, S., Schurer, A., & Cowan, T. (2018). The early 20th century warming: Anomalies, causes, and consequences. *Wiley Interdisciplinary Reviews: Climate Change, 9*(4).

Intergovernmental Panel on Climate Change (IPCC). (2019). *The physical science basis: Special report on climate change*. Retrieved March 10, 2025, from https://www.ipcc.ch/report/ar6/wg1/

Intergovernmental Panel on Climate Change. (2022). *Climate change 2022: Mitigation of climate change* (AR6 WGIII). Cambridge University Press. https://www.ipcc.ch/report/ar6/wg3/

Kaman, D., & Bozkurt, Y. (2025). Sürdürülebilir kalkınma ve çevre: Geleceği şekillendirecek stratejiler. *Dumlupınar Üniversitesi Sosyal Bilimler Dergisi, 83*, 299–316. https://doi.org/10.51290/dpusbe.1581194

Kanniah, K. D., Zaman, N. A. F. K., Kaskaoutis, D. G., & Latif, M. T. (2020). COVID-19's impact on the atmospheric environment in the Southeast Asia region. *Science of the Total Environment, 736*, 139658. https://doi.org/10.1016/j.scitotenv.2020.139658

Kaya, E., & Uzun, O. (2024). Kentsel açık ve yeşil alan planlamasında katılımcılık görüşlerini birlikte kullanan uluslararası çalışmaların bibliyometrik analizi. *Kent Akademisi Dergisi, 17*(3), 1060–1085.

Ketrez, G. (2024). *Karbon ayak izi araştırmalarının sağlık sektörü bağlamında görsel bibliyometrik haritalaması: Giresun Üniversitesi örneği*. Giresun Üniversitesi.

Khattra, S. K., Singh, D., & Dogra, R. (2024). A review of energy efficient technology and carbon trading for reducing carbon emissions. *Archives of Current Research International, 24*(6), 208–222.

Lindawati, A., & Meiryani, L. (2024). A bibliometric analysis on the research trends of global climate change and future directions. *Journal of Information and Policy Development, 8*(7), 33–49. https://doi.org/10.24294/jipd.v8i7.4551

Lobus, N. V., Knyazeva, M. A., Popova, A. F., & Kulikovskiy, M. S. (2023). Carbon footprint reduction and climate change mitigation: A review of the approaches, technologies, and implementation challenges. *Climate, 9*(4), 120. https://doi.org/10.3390/c9040120

Majahana, J. M., Kalumba, A. M., Zhou, L., Mazinyo, S. P., & Afuye, G. A. (2025). Climate change adaptation policy and governance in the water sector. *Environmental Science and Pollution Research*. https://doi.org/10.1007/s11356-025-21367-1

Marvin, W. J., & Augustine, Y. (2025). Carbon footprint: A bibliometric analysis. *Technium Social Sciences Journal, 67*(1), 15–30. https://doi.org/10.47577/tssj.v67i1.12387

Özyürek, H. (2024). The trends in carbon emissions, climate change, carbon footprint, carbon tax, green technology diffusion from 2015 to 2024: A bibliometric and visual analysis. *The Eurasia Proceedings of Science, Technology, Engineering & Mathematics, 27*, 1–15. https://doi.org/10.55549/epstem.1517767

Parsons, M., Asena, Q., Johnson, D., & Nalau, J. (2024). A bibliometric and topic analysis of climate justice: Mapping trends, voices, and the way forward. *Climate Risk Management, 43*, 100593. https://doi.org/10.1016/j.crm.2024.100593

Penz, E., & Polsa, P. (2018). How do companies reduce their carbon footprint and how do they communicate these measures to stakeholders? *Journal of Cleaner Production, 195*, 1125–1138. https://doi.org/10.1016/j.jclepro.2018.05.142

Rehman, S., Hasan, A., Singh, V., & Almaqtari, F. A. (2024). Decoding the complex relation of financial development and carbon emission using bibliometric analysis. *Cogent Economics & Finance*. https://doi.org/10.1080/23311975.2023.2294524

Rogelj, J., den Elzen, M., Höhne, N., Fransen, T., Fekete, H., Winkler, H., Schaeffer, R., Sha, F., Riahi, K., & Meinshausen, M. (2016). Paris Agreement climate proposals need a boost to keep warming well below 2°C. *Nature, 534*(7609), 631–639. https://doi.org/10.1038/nature18307

Sahane, P., Nalawade, P. J., Bhamare Vaishnav, S., Jagtap, U., & Bhosale, A. (2024). Industry specific carbon emission reduction techniques: A comprehensive survey. In *IEEE I-SMAC 2024 Conference Proceedings* (pp. 414–420). JSPM's Rajarshi Shahu College of Engineering, Pune, India.

Schneider, L., Konter, O., Esper, J., & Anchukaitis, K. J. (2023). Constraining the 19th century temperature baseline for global warming. *Journal of Climate, 36*(18), 1–33.

Setiawan, D., Rahmawati, I. P., & Santoso, A. (2023). A bibliometric analysis of evolving trends in climate change and accounting research. *Cogent Business & Management, 10*(1), 2267233. https://doi.org/10.1080/23311975.2023.2267233

Sökmen Gürçam, Ö., & Gürçam, S. (2022). İklim değişikliği ve sürdürülebilir kalkınma: Scopus veritabanına dayalı bibliyometrik bir analiz. *Pamukkale University Journal of Social Sciences Institute*. https://doi.org/10.30794/pausbed.1088762

United Nations. (2019). *Global sustainable development report 2019: The future is now – science for achieving sustainable development*. https://sdgs.un.org/publications/global-sustainable-development-report-2019-24419

United Nations Environment Programme. (2023). *Emissions gap report 2023*. UNEP. https://www.unep.org/resources/emissions-gap-report-2023

United Nations Framework Convention on Climate Change. (2015). *The Paris Agreement*. https://unfccc.int/process-and-meetings/the-paris-agreement/the-paris-agreement

United Nations Framework Convention on Climate Change (UNFCCC). (2022). *Adaptation and resilience in the face of climate change*. Retrieved April 3, 2025, from https://unfccc.int/sites/default/files/resource/UNClimateChange_AnnualReport_2022.pdf

Usta, G. (2023). İklim krizi ve iklim değişikliği araştırmalarının bibliyometrik analizi. *Biyolojik Çeşitlilik ve Koruma*. https://doi.org/10.46309/biodicon.2023.1299667

Van Eck, N. J., & Waltman, L. (2010). Software survey: VOSviewer, a computer program for bibliometric mapping. *Scientometrics, 84*(2), 523–538.

Vishvas, R. (2024). The role of policy and innovation in environmental sustainability. *Journal of Sustainable Solutions, 1*(2), 13–18.

Wang, Z. J. (2024). Analysis of carbon reduction potential based on carbon flow theory. *Applied and Computational Engineering, 93*(1), 134–140.

Weart, S. (2015). Climate and climate change. In *History of Scientific Work on Climate Change* (pp. 87–89). https://doi.org/10.1016/B978-0-12-382225-3.00491-6

Widianingsih, L. P. (2024). Can renewable energy, carbon taxes, and economic growth mitigate countries' carbon emissions? *International Journal of Energy Economics and Policy, 15*(1), 103–109.

Wiedmann, T., & Minx, J. (2008). A definition of carbon footprint. *Ecological Economics Research Trends, 1*, 1–11.

Xu, X. R., Gou, X., Zhang, W., Zhao, Y., & Xu, Z. (2023). A bibliometric analysis of carbon neutrality: Research hotspots and future directions. *Heliyon, 9*, e18763. https://doi.org/10.1016/j.heliyon.2023.e18763

Zhao, S., Wang, X., Li, C., & Chen, L. (2023). Visual analysis of international carbon emissions literature and study of evolutionary trends based on scientific knowledge mapping. *Journal of Policy Research, 5*(2), 44–60.

Zheng, Y., Li, Z., & Chai, J. (2023). Progress and prospects of international carbon peaking and carbon neutral research based on bibliometric analysis (1991–2022). *Frontiers in Energy Research, 11*, 1121639. https://doi.org/10.3389/fenrg.2023.1121639

EXTENDED ABSTRACT

Introduction and Research Questions & Purpose

Since the Industrial Revolution, rapidly increasing industrial activities, rising energy consumption, and the intensive use of fossil fuels have significantly increased the accumulation of greenhouse gases in the atmosphere. This process has led to the intensification of environmental problems such as global warming and climate change. The fact that these changes in the climate system are largely human-induced has shifted the focus of scientific research toward measuring and mitigating anthropogenic impacts.

In this context, the concept of the “carbon footprint” has emerged as an important indicator used to quantify the total greenhouse gas emissions caused directly or indirectly by individuals, institutions, and countries. The carbon footprint plays a critical role not only in assessing environmental impacts but also in developing sustainable development policies. In line with the goals of transitioning to a low-carbon economy, there has been a significant increase in academic studies on carbon footprint in recent years.

Despite this rapid growth, there remains a need for a comprehensive evaluation of the general trends in the literature, the areas of concentration, and the topics that have been insufficiently addressed. Therefore, a systematic examination of carbon footprint research is essential for understanding the existing body of knowledge and identifying future research directions.

Research Questions & Purpose

The main purpose of this study is to conduct a bibliometric analysis of academic publications on carbon footprint between 2011 and 2025 in order to identify trends, focal points, and research

gaps in the literature. In this regard, the study aims to analyze the development of the field through quantitative data and provide a framework to guide future research.

The study seeks to answer the following research questions:

- What is the annual distribution of academic publications in the field of carbon footprint?
- In which disciplines are carbon footprint studies most concentrated?
- Which countries produce the highest number of publications, and what does this distribution indicate?
- What are the most frequently used keywords in the literature, and how do they reflect research trends?
- What insights do citation analyses provide regarding the academic impact of carbon footprint studies?
- Which areas in the literature remain underexplored and present opportunities for future research?

In line with these questions, the study aims to present a comprehensive overview of the current state of carbon footprint research and to highlight the need for more interdisciplinary approaches, particularly within the social sciences.

Methodology

This study employs a bibliometric analysis method to examine the development of carbon footprint literature. Bibliometric analysis is a systematic approach that evaluates academic publications through quantitative data, enabling the identification of research trends, impact levels, and knowledge structures within a specific field.

The data collection process was conducted in January 2025. Two widely recognized international academic databases, Scopus and Web of Science (WOS), were selected as data sources. Based on predefined keywords, the search identified a total of 9,335 publications in Scopus and 6,642 publications in WOS published between 2011 and 2025.

The collected data were filtered according to specific inclusion and exclusion criteria. Duplicate records were removed, irrelevant studies were excluded, and a final sample of 111 articles was selected for in-depth analysis.

The analysis focused on the following bibliometric indicators:

- Annual distribution of publications
- Country-based academic productivity
- Disciplinary distribution
- Keyword analysis
- Citation counts and impact levels

The data were analyzed comparatively to identify patterns, trends, and relationships within the literature. This methodological approach enabled a systematic evaluation of the evolution of carbon footprint research, its main areas of focus, and potential gaps for future studies.

Results and Conclusions

This study provides a comprehensive bibliometric overview of carbon footprint research published between 2011 and 2025, highlighting key trends, dominant research areas, and existing gaps in the literature. The findings confirm that carbon footprint has become a central topic in climate change research and sustainability discourse.

One of the key conclusions is that, although the field has grown significantly, it is still largely dominated by technical and environmental disciplines. Therefore, there is a clear need to strengthen research in the social sciences to better understand behavioral patterns, policy implications, and societal impacts related to carbon emissions.

Additionally, the geographical concentration of publications in developed countries points to an imbalance in global research contributions. Enhancing research capacity in developing countries and promoting international collaboration are essential for achieving a more inclusive and comprehensive understanding of carbon footprint issues.

The study also highlights the importance of emerging themes such as renewable energy and sustainability, which are expected to continue shaping future research directions. However, further studies are needed to address underrepresented areas and integrate multidisciplinary perspectives.

In conclusion, this research offers a strategic foundation for understanding the evolution of carbon footprint literature and provides valuable insights for academics, policymakers, and practitioners working toward mitigating climate change and promoting sustainable development.