

Mapping carbon trading research with bibliometric analysis during 2005-2024

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Abstract. Air pollution is a problem that is worried about the whole world, including Indonesia. This problem causes serious impacts on environmental sustainability and public health. This study aims to identify research, references, and research trends related to Air Emission Trade that are being promoted to overcome the above problems. The analysis was carried out using 2,084 articles indexed by Scopus as references, starting from the period of 2005 - 2024 using the bibliometric method. This method is done by collecting relevant articles through databases available in reputable indexers, in order to analyze and evaluate scientific information. Through this approach, the researcher mapped the results of the study by highlighting the countries, authors, and institutions with the highest productivity and number of referrals. The provisional findings show that China, the United States, and the United Kingdom dominate in the number of articles and references. The main themes of the research identified are air pollution, economic growth, government policies, and emissions trading. This study highlights air pollution as a major problem that requires special attention. With bibliometric data, this study provides broad insights into the direction and focus of global research, related to carbon trading and the implementation of emissions trading policies in developing countries. It is hoped that the results of this study can be a foundation for various parties to formulate effective strategies or policies in dealing with the issue of air pollution for the sake of sustainable economic growth.

1 Introduction

The main issue and the most pressing global challenge is the greenhouse gas emissions that have a huge impact on climate change that occurs during the 21st century. In response to this issue, various international frameworks are being put in place to encourage the development of market-based policies aimed at reducing emissions efficiently [1]. Carbon trading is one of the approaches developed as a means of mitigating climate change. This mechanism has been widely applied in various developed and developing countries.

The increasing urgency of the topic has led to a significant expansion in the academic literature on carbon trading. Therefore, this study uses the bibliometric method as the main analysis method by utilizing the existing database on scopus to identify research trends,

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collaboration trends, and thematic focus on the global literature. This study focuses on three main trend focuses: (1) Carbon trading (2) Environmental sustainability (3) Climate change.

Carbon trading is a market mechanism that allows a country or business to buy and sell greenhouse gas emissions. In a global context, carbon trading is a very important tool to achieve climate change mitigation goals. Environmental sustainability highlights the importance of balancing human and environmental needs.

This concept explains the preservation of natural resources in a way that allows the current generation to enjoy them without worrying about the future. As a result of industrial activities and urbanization, research on sustainability is becoming increasingly relevant. Climate shift refers to long-term weather patterns caused by increased concentrations of gases in greenhouses. These include rising global temperatures, melting ice at the poles, and increasing frequency of natural disasters [2, 3]. Due to its urgency to the sustainability of human life and the planet, this topic has become the main focus of various studies and research. In addition, although tools such as Biblioshiny have been used to map collaborative networks, there has not yet been a comprehensive synthesis that integrates environmental, economic, and social dimensions in a single analytical framework.

In this context, bibliometric research offers a systematic methodological framework for exploring the research landscape related to carbon trading [4]. By utilizing quantitative analysis of scientific publications, this approach allows for the identification of topic trends, researcher collaboration, and conceptual developments in the field. This study uses data sources from structured databases obtained from scopus and biblioshiny as facilitators to map the related data. This study not only highlights how carbon trading policies can address climate change issues but also encourages cross-border collaboration by developing adaptable predictive models tailored to local contexts in developing regions. The findings reveal that developed countries dominate in terms of publication and collaboration and offer a fair research access platform to address local and global challenges. So, based on this topic, the formulation of the problem is as follows:

- RQ.1 How are the dynamics and development of scientific research related to carbon trading reflected in academic publications from 2005 - 2024?
- RQ.2 What are the key themes and strategic keywords that dominate academic discourse in this field, and how are they related to each other?
- RQ.3 What are the main profiles and sources of scientific literature related to Carbon Trading?
- RQ.4 How can research related to carbon trading contribute to achieving the Sustainable Development Goals (SDGs), especially on environmental sustainability and climate change mitigation?

2 Methods

This study uses bibliometric methods to map the development and trends of research related to carbon trading in a socio-economic context. The selection of the bibliometric method is considered appropriate because it is able to quantitatively analyse the development of literature on a large scale, identify collaboration patterns, topic trends, and relationships between concepts through citation data and keywords. The main advantage of this method lies in its ability to provide *Letter* comprehensive for the next researcher by revealing *Research gap* and existing knowledge structures. The Scopus database was chosen as the primary data source due to its extensive and well-indexed scope, internationally recognized reputation, and analytical facilities that facilitate systematic data extraction such as the number of publications, citation patterns, and keyword networks [5].

2.1 Data filtering process

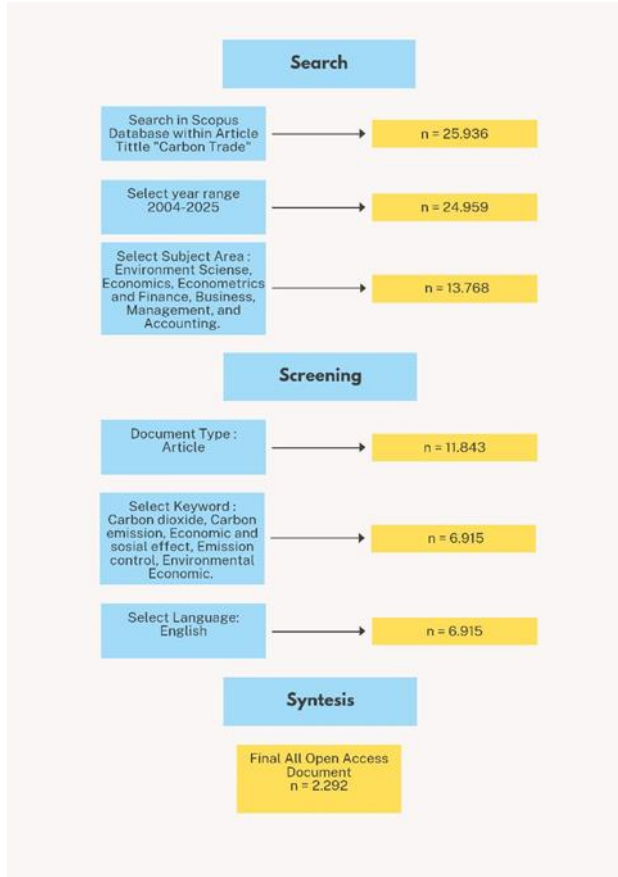


Fig. 1. PRISMA model

The data filtering process began with an initial search using the common keyword "carbon trade" which resulted in 25,936 documents. The 2004-2025 range was then applied to ensure the scope of this study was relevant to contemporary developments, leaving 24,959 documents. The focus was then narrowed to three main areas that are in harmony with the socio-economic context, namely Environmental Science; Economics, Econometrics, and Finance; and Business, Management, and Accounting, resulting in 13,768 documents. Further screening was carried out by limiting the type of documents in journal articles to ensure academic quality, resulting in 11,843 documents.

The next crucial screening stage applies five specific keywords: "Carbon Dioxide; Carbon Emission; Economic And Social Effects; Emission Control; Environmental Economics" to ensure high thematic relevance to the research focus. This process screened 6,915 documents that were then limited to an equal number of English-language publications. The final criteria of open access were applied to ensure the affordability and accessibility of the literature, resulting in 2,292 documents that were ready for further analysis. This entire filtering process ensures that the analysed data has strong thematic relevance and guaranteed methodological quality.

3 Results and discussion

From the database obtained through Scopus, it can be seen that research on carbon trading has increased significantly in the period 2004-2025. This is expressed by the annual growth rate, increasing by 34.55% per year. The age of research documents from this topic is relatively young with an average document age of 5.04 years. The development of research on this topic can also be seen in the number of references that use research on this topic, the average number of referrals is 41.04 per year. With a total of 2084 documents, research on this topic uses 16028 references.

3.1 Annual scientific production

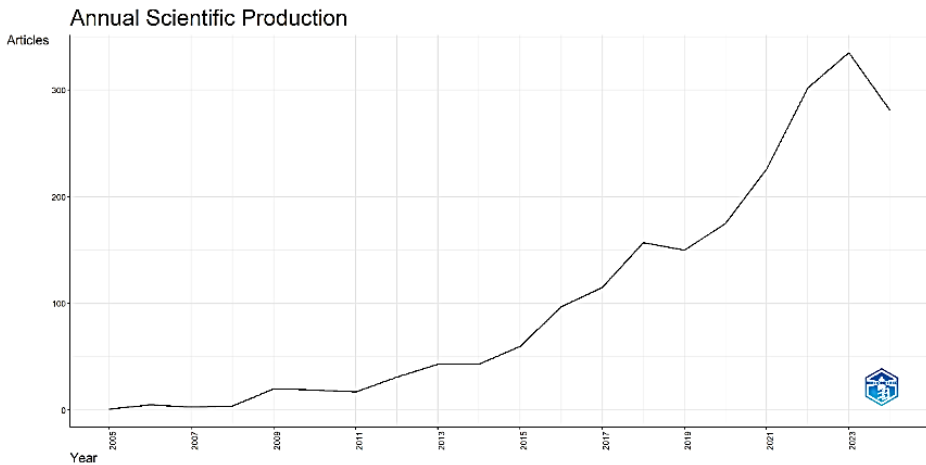


Fig. 2. Annual scientific production

In 2015, there was a Paris Agreement which discussed climate change with the aim of limiting the global temperature rise to well above 2 degrees Celsius. This year, there was an increase in the release of documents where in the previous year there were only 43 documents, while in 2015 there were 60 documents. This year, the most sought-after and referenced article is "Carbon pricing versus emissions trading: A supply chain planning perspective" which discusses the comparison between the implementation of carbon taxes and carbon trading. In 2020, there was a covid-19 pandemic that made major changes in human life. This year, the number of document releases increased again from the previous year only 150 documents, to 175 documents released in 2015. This year, the most searched and referenced article is "An empirical analysis of the non-linear impacts of ICT-trade openness on renewable energy transition, energy efficiency, clean cooking fuel access and environmental sustainability in South Asia" which discusses the non-linear impact of ICT-Trade on the environment and energy [6]. In 2024 when this research was conducted, it was recorded that the number of document releases regarding carbon trade has decreased. This is evidenced by the number of data published in 2023 reaching 335 documents, while in 2024 the number of document releases will only be 281 documents. This year's most sought-after article is "Environmental and socio-economic effects of construction and demolition waste recycling in the European Union" which discusses the effects of construction waste recycling on the environment and from a socio-economic perspective. The similarity of the three articles is that they discuss the impact of emissions on the environment and research on something that can be a solution in the future.

3.2 Most productive sources

Table 1. Top sources

Sources	Articles
Sustainability (Switzerland)	314
Environmental Research Letters	117
Ecological Indicators	112

Sustainability (Switzerland) is the most productive source with a total of 314 articles. Article written by Teixeira et al., (2025) [3] with the title "Economic growth and climate change: A cross-national analysis of territorial and consumption-based carbon emissions in high-income countries" is the most referenced article with the number of references reaching 207. The analysis of the relationship between economic growth and climate change in high-income countries, is the main discussion in this article. ENVIRONMENTAL RESEARCH LETTERS is the second largest source after Sustainability (Switzerland), the number of articles published on this topic amounts to 117 documents. The title of this source that is widely used as a reference is an article written by Zheng et al. 2020 [7] entitled "Regional determinants of China's consumption-based emissions in the economic transition" with a total of 308 references. This article discusses the new policies that China implemented after the covid-19 pandemic to reduce carbon emissions. The third source that is active in releasing articles on this topic is ECOLOGICAL INDICATORS, this source has managed to release 112 documents with a large number of references. As in the title written by Ertugrul et al., (2016) [8] "The impact of trade openness on global carbon dioxide emissions: Evidence from the top ten emitters among developing countries" which was referenced as many as 384. This shows that the large number of article releases does not necessarily get as many references as sources with fewer article releases. In this study, ECOLOGICAL INDICATORS, which is ranked third in productivity, gets a higher number of referrals than the first order. The similarity of the article above is what they discuss, namely the impact and analysis of carbon and its policies on the environment.

3.3 Most productive authors

Table 2. Top authors

Author	H-index	g-index	m-index	Total Citation	Number of Publication	PY-Start
Guan Dabo	18	20	1.800	1484	20	2016
Meng Jing	17	18	1.889	1366	18	2017
Van Vuuren Detlef P.	14	16	0.778	1117	16	2008
Feng Kuishuang	12	13	1.200	919	13	2016
Shan Yuli	10	12	1.000	973	12	2016

Guan Dabo took the first position with 20 article publications. The total referrals obtained by Guan Dabo are relatively high, with a total of 1484 referrals. Article titled "New provincial CO2 emission inventories in China based on apparent energy consumption data and updated emission factors" is the article with the highest number of references, namely 569 references. In the same field, an article by Hertwich & Peters, (2009) [9] The one titled "Carbon footprint of nations: A global, trade-linked analysis" received a high reference of 1410. Both articles have similarities in the content of the discussion regarding carbon analysis. This information shows a basis for searching for research topics armed with the data of the most active authors to develop the content of the discussion in the next research.

3.4 Countries' scientific production

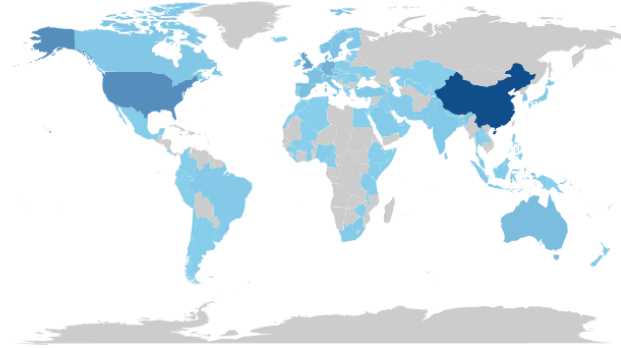


Fig. 3. Most productive countries

The country that has produced the most articles related to carbon trading is China with a total of 2,333 articles that have been produced on the topic of carbon trading. Some of the articles produced by Chinese researchers related to carbon trading in a socio-economic context include articles written by Li et al (2024) [10] with the title "Research on the Connection Market Trading Issues of Green Certificates and CCER Based on Contribution Degree and Social Welfare". The article discusses how best to connect the "carbon coupon" market (CCER) with the "green electricity certificate" market, so that the two can reinforce each other in achieving national carbon reduction targets. Next is the article discussed by Li et al (2024) [10], the main discussion was related to the impact of environmental investments made by China and Pakistan on Pakistan's economy, environment, and energy security. The findings of this study are all types of energy investments (from coal to renewables) have succeeded in increasing the proportion of clean electricity and reducing CO₂ emissions, the economic impact varies greatly depending on the energy source. In addition, this study also describes research collaboration between China and Pakistan. The next country to produce research related to carbon trading in a socio-economic context is the USA with the number of research produced is 1,120 articles. One of the studies produced by the USA is a study entitled "Effect of green bonds, oil prices, and COVID-19 on industrial CO₂ emissions in the USA: Evidence from novel wavelet local multiple correlation approach". The focus of this study was to analyze the influence of green bonds, oil prices, and the COVID-19 pandemic on industrial CO₂ emissions in the U.S. with weekly data, using an advanced statistical approach (WLMC) that takes into account changes in time and frequency [11]. The next country with the highest number of carbon trading research is the UK with a total of 769 articles produced, Germany with 477 articles produced, and the Netherlands with a total of 332 articles related to carbon trading in socio-economic contexts with the fifth most people.

3.5 Thematic evolution

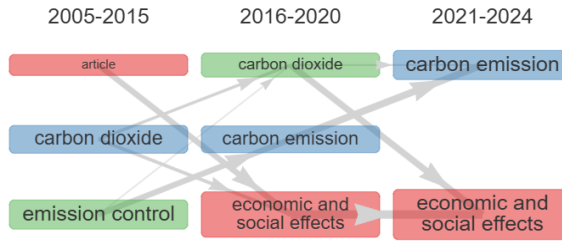


Fig. 4. Thematic evolution

In the early period (2005-2015), research focused primarily on basic concepts such as "carbon dioxide" and "carbon emissions," reflecting early scientific interest in measuring and understanding emissions. However, following the adoption of the Paris Agreement in 2015, the period 2016 to 2020 shows the transition towards "emissions control" as the main theme. This indicates a growing emphasis on regulatory mechanisms and carbon trading systems to achieve mitigation goals, as reflected in a study on the EU's emissions offset strategy that uses tools such as PLEDGES to distribute carbon budgets equitably among member states, highlighting the impact of the agreement on research priorities [12].

The most recent period (2021-2024) marks a significant expansion into "economic and social effects," particularly the COVID-19 pandemic, have reshaped the research landscape. The pandemic disrupted global supply chains and industrial activity, triggering studies examining the dynamic interactions between carbon emissions and socio-economic factors. For example, research in the US shows how COVID-19 initially reduced emissions in the medium term but also triggered long-term economic considerations [11]. Similarly, studies on green supply chain emphasize the trade-off between emissions reductions and economic efficiency during disruptions, illustrating the broader integration of socio-economic dimensions into carbon trading discourses to address real-world challenges [13-15].

4 Conclusion

Based on a bibliometric analysis of 2,084 Scopus-indexed articles published between 2005 and 2024, this study concludes that research on carbon trading has grown rapidly and evolved into a highly interdisciplinary field integrating environmental, economic, and policy perspectives. The findings indicate that scholarly output is dominated by developed countries—particularly China, the United States, and the United Kingdom—reflecting their strong research capacity and policy engagement in emissions trading systems, while contributions from developing countries remain limited. The thematic evolution reveals a clear shift from early studies focusing on carbon emissions measurement toward more complex analyses of emissions control mechanisms, economic growth, government policies, and socio-economic impacts, especially following the Paris Agreement and during the COVID-19 pandemic. Overall, the results demonstrate that carbon trading is increasingly positioned as a strategic market-based instrument for climate change mitigation and environmental sustainability, supporting the achievement of the Sustainable Development Goals (SDGs). This study provides a comprehensive overview of global research trends and highlights the need for future studies to develop more context-sensitive carbon trading models that are applicable to developing economies and capable of balancing environmental effectiveness with socio-economic considerations.

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