CARBON EMISSION REDUCTION IN THE CONTEXT OF GREEN TRANSITION: A BIBLIOGRAPHIC ANALYSIS OF STUDIES FOR THE PERIOD 2020-2024

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Abstract

As climate change intensifies, reducing carbon dioxide (CO_2) emissions has become a central pillar of sustainable development and global climate action. Countries around the world, such as China, Germany, and India, are adopting green transition policies encompassing renewable energy, green finance, and industrial restructuring. While existing studies have explored various aspects of green transition and carbon mitigation in specific fields, such as green finance, industrial restructuring, and sector-specific approaches, there is a lack of comprehensive analysis connecting these diverse domains globally. This study aims to bridge this gap by conducting a bibliometric analysis using data from the Scopus database. Bibliometric methods have been extensively applied in research areas like education, entrepreneurship, and social media, offering insights into publication patterns, collaboration networks, and thematic development. By applying bibliometric analysis to the topic of carbon dioxide emissions reduction in the context of green transition, this study identifies key research trends, influential authors and journals, and emerging topics that shape the landscape of carbon mitigation efforts worldwide. The findings provide a broad overview of the interdisciplinary connections among technology, economy, and policy, and they are beneficial to stakeholders and policymakers striving to achieve carbon neutrality and sustainable development goals.

Keywords: *Carbon emission reduction, Environmental regulation, Green transition, Sustainable development, International comparison, Bibliometrics.*

1. INTRODUCTION

Carbon emissions reduction is one of the most urgent problems confronting the world as climate change intensifies. In the absence of efforts to mitigate carbon dioxide (CO_2) emissions, which constitute 84% of greenhouse gas emissions (Ma et al., 2019), the world will struggle to adjust to the consequences and severity of this problem in the future, and the ultimate magnitude of climate change depends strongly on the actions that human societies take to respond to these risks (Hansen et al., 2001). In response to the circumstances affecting millions of people due to this phenomenon, including record temperatures and the significant increase in atmospheric CO_2 concentrations in 2016 (Hansen et al., 2001), countries around the world are actively formulating and implementing long-term development plans aimed at reducing carbon emissions (Al-Omar et al., 2023). The reduction of carbon emissions has become a fundamental component of sustainable development efforts, alongside international obligations such as the Paris Agreement, which aims to limit the increase in global temperatures to well below 2°C above pre-industrial levels. (*Energy & Climate Intelligence Unit | The Paris Climate Agreement*, n.d.)

To achieve this goal, nations including China (Dong & Zhu, 2023), Pakistan (Mehmood et al., 2024a), Germany (*German Emissions Fell 3.4% in 2024, on Track for 2030 Climate Goals | Reuters*, n.d.), India (Sen & Sahoo, 2024), and Saudi Arabia (Mukhtarov et al., 2024) are driving the shift toward green transition. This process involves transitioning from fossil fuels to renewable energy sources such as wind and solar through an integrated system including technology, politics, infrastructure, and culture (Song et al., 2020a). As these countries implement green transition by focusing on the

development of circular economy policies (Ramčilović Jesih et al., 2024), advancing green finance (Xiao et al., 2024; L. Zhao et al., 2023), green technology (Hu et al., 2024a), green agriculture (S. Wang et al., 2023), industrial transformation mechanisms (Han et al., 2023; Y. Liu et al., 2024), and carbon pricing (Sen & Sahoo, 2024) to achieve carbon neutrality, they have made significant contributions to climate change mitigation and moving towards sustainable development.

There have been a large number of research documents on carbon reduction and green transition across the aforementioned fields. For instance, Di Chen, Haiqing Hu et al. (Chen et al., 2024) and Mingzhong Hua, Zhe Li et al. (Hua et al., 2024) studied the impact of green finance on green transition. S. Mehmood, K. Zaman, and S. Khan et al. indicate the role of green industrial transformation and the importance of environmental policies in minimizing carbon emissions, including carbon pricing, command-and-control mechanisms, and incentive-based regulations (Mehmood et al., 2024a). In addition, some, some previous study aimed to look at the green transition in the building sector (Song et al., 2020a) and the sports industry (Dong & Zhu, 2023) and how they can mitigate carbon emissions.

However, there is a lack of comprehensive analysis of mitigating carbon at a global scale, as well as the connection between fields such technology, economy, finance, agriculture and policy in the process of reducing carbon emissions. The coordination of strategies for reducing carbon emissions across sectors was highlighted, emphasizing the integration of industrial restructuring, pollution control, ecological protection, and climate change response to effectively reduce carbon emissions and pollution and promote green expansion and growth (Nie & Lee, 2023). Hence, this study aims to fill this gap by conducting a bibliometric analysis on reducing carbon dioxide emissions in the context of green transition with data obtained from the Scopus database. Bibliometric analysis is widely used to draw a comprehensive picture of particular research topics such as education (Gümüş et al., 2020a), entrepreneurship (Chandra, 2018), tourism (Szpilko, 2017a), social media (Ha et al., 2021), and machine learning (Çağlayan Akay et al., 2022). It helps to capture various features from the existing literature on reducing carbon emissions, including the number of related articles over a longitudinal perspective, the geographical distribution of authors, co-author collaboration patterns, major sources of publication, major authors, and research groups or topics.

Although several bibliometric studies have examined carbon emission-related issues, most of them have concentrated solely on particular sectors, like carbon tax (K. Zhang et al., 2016), tourism (Mishra et al., 2022), and education (Hudha et al., 2020). These studies provide valuable insights, but their scope is largely confined to a single aspect of carbon research. Notably, the bibliometric study "From low carbon to carbon neutrality: A bibliometric analysis of the status, evolution and development trend" (Z. Zhang et al., 2022) provided a comprehensive overview of research on carbon neutrality, highlighting the primary contributors in publications and emphasizing that achieving carbon neutrality requires an integrated approach across technology, economy, and society. Nevertheless, it did not systematically investigate the interconnections among other fields such as policy, finance and agriculture within the broader context of green transition. As a result, by using bibliometric analysis, our research provides a comprehensive overview of the interaction between green transition and carbon reduction across different fields and helps policymakers formulate comprehensive and effective strategies to cut down carbon emissions.

Specifically, it intends to address the following research questions (RQ):

RQ1: Which countries are the major contributors to research on this problem?

RQ2: Who are the most influential authors in this field?

RQ3: What are the key topics in carbon emission reduction?

2. METHODOLOGY

This review used bibliometric methods to examine trends and patterns in the scientific database relating to green transition. The bibliometric approach builds bibliometric networks based on knowledge downloaded from bibliographic databases (e.g., Web of Science or Scopus) (Zupic & Čater, 2015). The bibliometric analysis technique review aims to understand the trends and systemic structure of the knowledge base in different disciplines (White & McCain, 1998). Hence, differing from the traditional review method, the bibliometric analysis examines bibliographic metadata, which seeks to integrate substantive findings within a field of study (Zupic & Čater, 2015).

2.1 Search Criteria and Identification of Sources

There are two most common scientific databases, including Scopus and the Web of Science, which are often selected by previous authors for bibliometric review (J. Zhu & Liu, 2020). In this specific instance Scopus was chosen as the primary data source for the following reasons:

First, Scopus was selected because it applies a consistent indexing standard for document inclusion, as emphasized by Hallinger and Nguyen (Hallinger & Nguyen, 2020). Second, Scopus has more coverage than Web of Science (Aksnes & Sivertsen, 2019; Hallinger & Chatpinyakoop, 2019; Mongeon & Paul-Hus, 2016), particularly in the fields of social sciences and humanities (Martín-Martín et al., 2018).

The search for documents on the topic of green transition encompassed articles and conference papers. The search query was conducted on the 17th of February in 2025. The publication time frame was restricted to documents published between 2020 and December 2024. Regarding the languages of searched publications, following Hallinger and Chatpinyakoop (Hallinger & Chatpinyakoop, 2019), only English-language publications were considered, thereby ignoring other languages, including Chinese, French, Spanish, and Bahasa Indonesia. Because of this, one limitation of this research is its ignorance of non-English publications.

Eventually, the following keywords were used for the search query: TITLE-ABS-KEY ("Green transition*" OR "Green

Transition*") AND (EXCLUDE (PUBYEAR , 2025)) AND (LIMIT-TO (DOCTYPE , "ar")) AND (LIMIT-TO (LANGUAGE , "English")) AND (LIMIT-TO (SUBJAREA , "SOCI") OR LIMIT-TO (SUBJAREA , "ECON") OR LIMIT-TO (SUBJAREA , "BUSI") OR LIMIT-TO (SUBJAREA , "DECI") OR LIMIT-TO (SUBJAREA , "MULT") OR LIMIT-TO (SUBJAREA , "ARTS") OR LIMIT-TO (SUBJAREA , "PSYC"))

In this study, the authors used the literature search guidelines established by the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) (Moher et al., 2009). Numerous scholars adhere to PRISMA for systematic evaluations across various fields, such as education (Hallinger & Chatpinyakoop, 2019), tourism (Szpilko, 2017b), and entrepreneurship (Cardella et al., 2020). PRISMA allows authors to make all steps in the process of quest and screening clear (Figure 1). Specifically, the first search query yields a preliminary result of 4352 documents. Next, following PRISMA, inclusion and exclusion criteria were applied to filter the dataset. Eligible criteria include (i) type of document: article and conference paper; (ii) language: English; and (iii) subject area: Business, Management, and Accounting; Social Sciences; Economics, Econometrics, and Finance; Decision Sciences; Arts and Humanities; Psychology; and Multidisciplinary. The initial Scopus search yielded 1671 documents. Following Gümüş et al.'s suggestion (Gümüş et al., 2020b), two co-authors scanned the titles and abstracts of articles to identify their relevance to the research questions. This step was undertaken between November 2024 and February 2025. At the final step, the comparison of the two co-authors yielded a 98% agreement on the inclusion/exclusion of articles. In cases of disagreement, a discussion was held between the two reviewers until a consensus was reached. In this final step, the authors removed 1584 non-conforming documents.

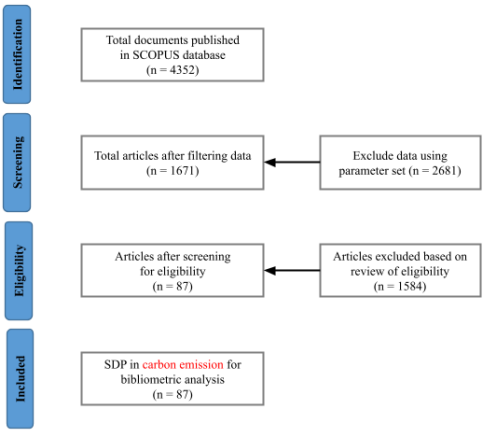


Figure 1: Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) flow diagram detailing steps in the identification and screening of sources for review of carbon emission reduction.

Eventually, a total of 87 publications were obtained for the final analysis (Figure 1).

2.2 Data Analysis

Bibliographic data (authors, titles, affiliations, citations, etc.) related to the 87 carbon emission reduction documents were exported from Scopus into a master Excel file. Excel was used to perform descriptive statistical studies to chart the landscape of carbon emission scholarship. (e.g., growth pattern, geographical distribution, types of research papers). VOSviewer software, a bibliometric tool for science mapping, was used to analyze data in this master Excel file. VOSviewer software is used to generate visual maps to illustrate citation analysis and co-citation analysis. The VOSviewer software package has been widely used in published reviews of research fields such as social sciences (Levallois et al., 2012; Leydesdorff et al., 2014), business and management (Mingers & Leydesdorff, 2015), medicine (Sweileh, 2017), and education (Hallinger & Hammad, 2019; Hallinger & Kovačević, 2019). The Biblioshiny package was also used to perform the extraction of related figures.

3. RESULTS AND DISCUSSION

This section presents the results and discussion of the bibliometric analysis of carbon emission reduction, which corresponds with the 3 research questions mentioned above.

3.1 Total volume, growth pattern, and geographical distribution of carbon emission reduction literature.

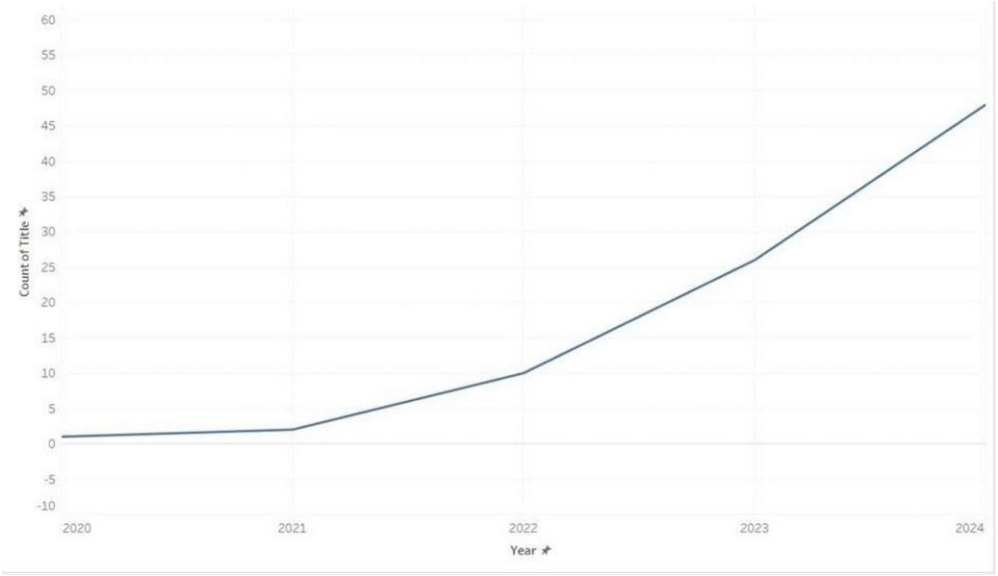


Figure 2: Growth pattern of carbon emission reduction literature in Scopus between 2020-2024

This subsection considers three aspects of studies on carbon emission reduction: total volume, growth pattern, and geographical locations.

The results obtained from the analysis of the database indicate 87 articles about carbon emission mitigation published between 2020 and 2024. The 2020–2024 timeframe is scientifically significant because it marks a clear turning point in both global climate policy and academic research. Prior to 2020, publications on carbon emission reduction were minimal, reflecting the absence of strong global frameworks. Figure 2 shows the documents on this topic over the years, starting with the first published study in 2020. The annual number of publications on carbon emission reduction has consistently risen, reflecting an increasing scholarly focus on this subject in recent years. The reason for this upward trend is the emergence of a series of important green transition policies. For example, the European Green Deal (2019) set the core objective of making Europe the first climate-neutral continent by 2050 (*The European Green Deal - European Commission*, n.d.). This ambition was reinforced by the EU Climate Law (2021), which translated the goal into binding legislation requiring net-zero emissions by 2050. In the same year, the "Fit for 55" package outlined concrete measures to reduce EU emissions by at least 55% by 2030, compared to 1990 levels (Bocquillon, 2024; *Regulation - 2021/1119 - EN - EUR-Lex*, n.d.). Especially, the 2021 United Nations Climate Change Conference (COP26) adopted the Glasgow Climate Pact, which includes several key commitments aimed at combating climate change and limiting global warming to 1.5°C above pre-industrial levels while calling on countries to reduce global carbon dioxide emissions by 45% by 2023 to attain net zero carbon dioxide emissions by around mid-century (*COP26 Ends with a Strong Result on Carbon Markets - Environmental Defense Fund*, n.d.). Each of these commitments marked an escalation in ambition, triggering a surge of scholarly attention to assess their feasibility and implications. Such attention is evidenced by the exponential growth of publications after 2021, making this period uniquely reflective of how international policy shifts directly shaped research agendas. To be specific, this increased trend significantly intensified in 2022, with 26 papers published in 2023 and 48 papers published in 2024. The data for 2024 (48 articles) is about 5 times greater than that of 2022 (10 articles), while 2020 and 2021 had only 1 and 2 documents, respectively. By concentrating on the post-COP26 phase as a "turning point" period, this research captures the most dynamic and policy-relevant stage of carbon reduction research and provides a novel and timely contribution to the literature.

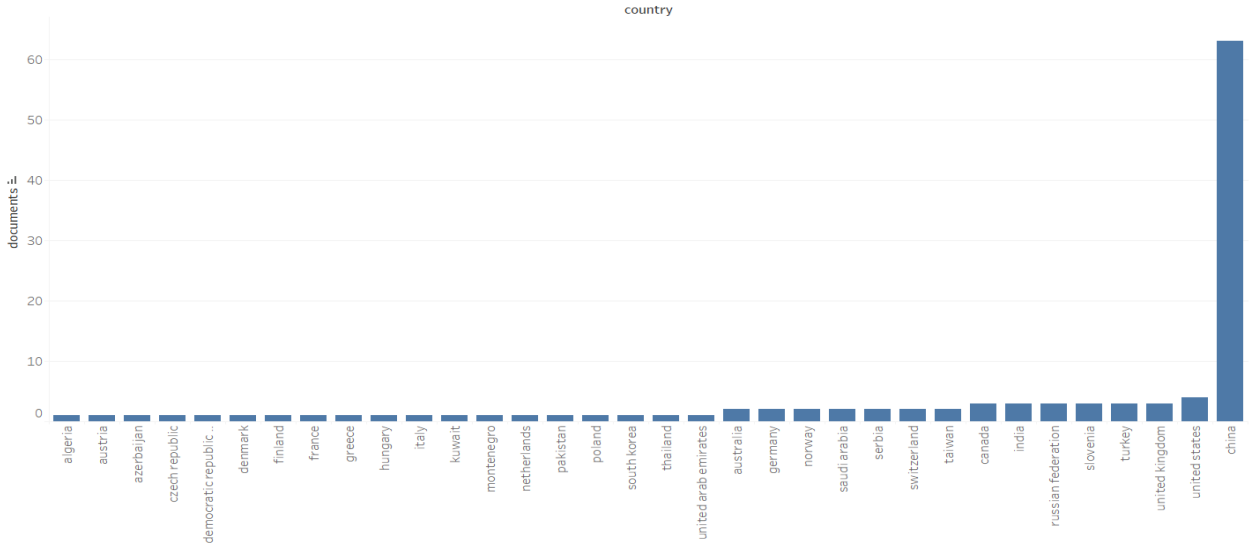


Figure 3: Geographical distribution of carbon emission reduction literature in Scopus between 2020-2024

Regarding geographical locations, 87 documents were co-authored by 298 scholars, distributed in 34 countries. However, to study the country distribution of publications, Figure 3 indicates that studies on this topic focus mainly on China, which possesses an absolute majority relative to other nations, with 63 documents constituting 53.39% of the total. After China, the United States follows as the second-largest contributor to the topic of carbon emission reduction, accounting for 3.39% (4 documents). Following the United States are the United Kingdom, Turkey, Slovenia, the Russian Federation, India, and Canada, which have the same proportion of 2.54% (3 documents). The following seven countries also make an equal contribution of 1.69% (2 documents) to the total documents. These countries are Taiwan, Switzerland, Serbia, Saudi Arabia, Norway, Germany, and Australia. The remaining nations contribute even less, with each representing 0.85% (only 1 document).

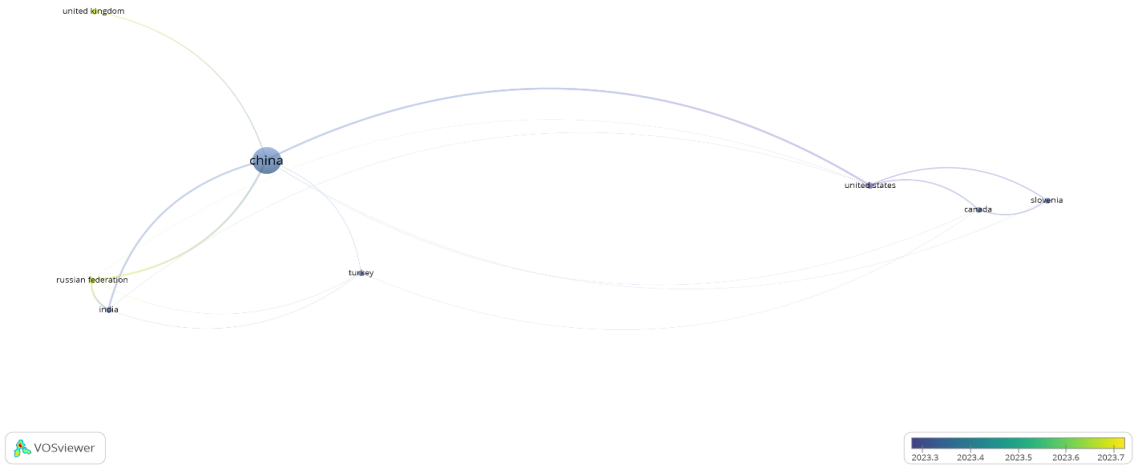


Figure 4: Co-author collaboration network by country from carbon emission reduction literature in Scopus between 2020-2024.

The country co-authorship map (Figure 4) illustrates the level and trends of research collaboration among nations that have had at least three documents over time. Each node represents a country that has scientific publications, and the size of the node indicates the frequency of occurrence, with larger nodes representing countries with more publications. The lines linking the nodes signify the co-authorship relationships among countries. The wider a line is, the more documents are co-published by authors from the two countries. Despite some international cooperation, each pair of countries contributed no more than one co-authored paper on carbon emissions reduction. Additionally, the colour of the nodes represents the experiences of the respective countries in the carbon emissions reduction literature. In particular, the timeline indicates that all significant contributions from different countries commenced in 2023, albeit at varying intervals within the year. The United States, Canada, and Slovenia participated first in this research area, as indicated by the purple nodes. Although China, India, and Turkey did not participate in the research field as early as the three given countries, their blue nodes still highlight their early involvement in carbon reduction (by April 2023). Lastly, it appears that co-authors from the UK and the Russian Federation, who have yellow nodes, are newcomers to this research topic.

This data provides information to answer the first research question regarding the major contributors to research on carbon emission reduction. Figure 3 and Figure 4 reveal that China holds a dominant position in this research area. Its number of

publications is more than 15 times greater than the United States, which ranks second with just 4 articles (3.39%). However, the United States is one of the first countries to research reducing carbon emissions, as evidenced by the publication of its first articles on the topic in the first quarter of 2023. Furthermore, although the publication distributions from other countries are geographically diverse, their counts remain relatively modest, with contributions ranging from 1 to 4 documents each, except China, which has 63 documents. These figures indicate a marked disparity in global engagement and investment, highlighting China's deep commitment and strategic focus on carbon emission reduction as a national research priority. Moreover, as mentioned above, all countries have collaborated on no more than a single publication in this area. This explains the restricted and disjointed nature of international research collaboration in this domain.

The reason for China's dominance in the number of publications on carbon emission reduction is the combination of strong national commitments, market-based policy instruments, substantial research capacity, and supportive academic incentives. To be specific, the government's "dual-carbon" commitment to peak emissions before 2030 and achieve neutrality by 2060 has established a significant strategic imperative that channels funding, institutional support, and scholarly attention toward low-carbon solutions (Y. Zhang et al., 2021a; C. Zhao et al., 2022). Besides, the implementation of market-based mechanisms such as the national Emissions Trading Scheme (ETS) in 2021 provides a large-scale natural experiment that generates unique datasets by aggregating emissions data from thousands of enterprises (J. Liu & Liu, 2023). This evidence promotes academic studies on allowance pricing, firm behavior, and market efficiency. As a result, researchers in China are able to produce more publications with strong data-driven analyses compared to countries without similar large-scale policy instruments. This advantage is reinforced by China's substantial R&D workforce and consistent government investment in research around 2.5% of GDP in recent years (*China's Expenditure on Research and Experimental Development (R&D) Exceeded 3.6 Trillion Yuan in 2024*, n.d.; *China's R&D Spending Reports Steady Growth in 2024*, n.d.; Kyriakopoulou et al., n.d.), which ensures a high volume and variety of academic output on carbon emission reduction. Moreover, the alignment between state funding programs and academic performance incentives prioritizes projects linked to national strategies, further enhancing publishing science research (Jiang & Ashworth, 2021; Xu, 2020). Collectively, these interrelated factors explain why China leads the world in research on carbon emission reduction beyond mere publication counts.

Building on these structural drivers, a more detailed analysis of documents published in China shows that this nation has devoted significant attention to the topic of environmental regulation and policy in the context of carbon emissions and green transition. The aforementioned strategic imperatives and policy frameworks significantly influence the subject focus of Chinese research, resulting in a thorough investigation of topics such as the design, implementation, and evaluation of regulatory mechanisms. This is evidenced in several recent publications that assess the efficacy of policies such as carbon emissions trading policy (C. H. Zhu et al., 2024), trans-provincial watershed eco-compensation policy (Q. Yang et al., 2024), low-carbon governance, fiscal decentralization (S. Liu et al., 2024), and heterogeneous environmental regulations (Tang et al., 2023). Furthermore, China has also devoted significant focus to the factors driving firms to undergo green transition. The literature in this domain emphasizes structural and perceptual elements, including digitalization (D. Wang & Dou, 2024), carbon risk awareness (Deng et al., 2024), and innovation ecosystem design (Hu et al., 2024b).

Table 1: Top 10 Active Journals Published in Carbon Emission Reduction Literature, 2020-2024.

TT	Source	TC	NP	PY
1	JOURNAL OF CLEANER PRODUCTION	111	4	2022-2024
2	ENERGY AND BUILT ENVIRONMENT	96	1	2024
3	SUSTAINABILITY (SWITZERLAND)	86	20	2022-2024
4	TECHNOLOGICAL FORECASTING AND SOCIAL CHANGE	67	2	2024
5	INTERNATIONAL JOURNAL OF CLIMATE CHANGE STRATEGIES AND MANAGEMENT	62	1	2023
6	ENVIRONMENTAL IMPACT ASSESSMENT REVIEW	55	1	2023
7	SUSTAINABLE CITIES AND SOCIETY	46	1	2023
8	ENERGY RESEARCH AND SOCIAL SCIENCE	37	1	2020
9	CHINESE JOURNAL OF URBAN AND ENVIRONMENTAL STUDIES	33	1	2021
10	ENVIRONMENT, DEVELOPMENT AND SUSTAINABILITY	25	5	2023-2024

Note: TC: total citations; NP: number of publications; PY: published year of the first document.

Turning to journals, Table 1 presents the top 10 most influential journals of carbon emission reduction. Among them, although the "Journal of Cleaner Production" published only four articles from 2022 to 2024, it emerges as the most influential journal, receiving the highest total citations (111). In contrast, "Sustainability (Switzerland)" ranks third in the number of total citations (86), while this journal is the most productive, with the highest number of publications (20) in the same period. Furthermore, the publication count of "Sustainability (Switzerland)" is quadruple that of "Environment,

Development, and Sustainability," which ranks second in the publication volume and has the lowest number of citations in the top 10 impact sources (25) during the initial period (2023–2024).

This figure highlights a disparity between publication volume and citation impact among the top-ranked journals in research on reducing carbon emissions, which is evidenced by the gap in total citations and publication counts in journals such as "Journal of Cleaner Production", “Energy and Built Environment”, “International Journal of Climate Change Strategies and Management”, “Environmental Impact Assessment Review”. Despite possessing a substantial citation count, these journals have published only one document. In contrast, while "Sustainability (Switzerland)" and "Environment, Development and Sustainability" occupy the first and second ranks among the most productive journals, they have just 20 and 5 documents, respectively. This discrepancy highlights that scholarly influence may be determined by other factors. Moreover, an examination of eight articles in the "Journal of Cleaner Production" - the most cited journal, reveals that the paper titled “A technical framework for integrating carbon emission peaking factors into the industrial green transition planning of a city cluster in China” (Zhou et al., 2022) accounted for approximately half of the overall citations (53) of this journal on this topic. This article proposes a technical framework to tackle the weakness faced when integrating industrial green transition (IGT)-associated issues with carbon emission peaking (CEP) factors during the development of IGT options. Besides, the second most influential journal published only one document titled “The role of green industrial transformation in mitigating carbon emissions: Exploring the channels of technological innovation and environmental regulation”, which studies the impact of GIT on carbon emissions (Mehmood et al., 2024b). To conclude, these two topics mentioned in the aforementioned papers have garnered considerable interest from scholars in the research field of carbon emission mitigation. This conclusion contributes to RQ2 by clarifying which topics have been receiving increasing attention from researchers.

3.2 The most influential authors and documents on carbon emission reduction

Table 2: Top 10 impact documents in carbon emission reduction literature, 2020-2024

TT	Document	Authors	Source	TC	Year
1	The role of green industrial transformation in mitigating carbon emissions: Exploring the channels of technological innovation and environmental regulation	Mehmood S.; Zaman K.; Khan S.; Ali Z.; Khan H.U.R.	Energy and Built Environment	96	2024
2	Research on the emission reduction effects of the carbon trading mechanism on the power industry: plant-level evidence from China	Han Y.; Tan S.; Zhu C.; Liu Y.	International Journal of Climate Change Strategies and Management	62	2023
3	Does digital dividend matter in China's green low-carbon development: Environmental impact assessment of the big data comprehensive pilot zones policy	Wei X.; Jiang F.; Yang L.	Environmental Impact Assessment Review	55	2023
4	Pathways towards carbon neutrality in low-carbon cities: The role of green patents, R&D, and energy use for carbon emissions	Abbas S.; Saqib N.; Mohammed K.S.; Sahore N.; Shahzad U.	Technological Forecasting and Social Change	55	2024
5	A technical framework for integrating carbon emission peaking factors into the industrial green transition planning of a city cluster in China	Zhou S.; Li W.; Lu Z.; Lu Z.	Journal of Cleaner Production	53	2022
6	Probing CO2 emission in Chengdu based on the STRIPAT model and Tapio decoupling	Yang F.; Shi L.; Gao L.	Sustainable Cities and Society	46	2023
7	Contested energy futures, conflicted rewards? Examining low-carbon transition risks and governance dynamics in China's built environment	Song L.; Lieu J.; Nikas A.; Arsenopoulos A.; Vasileiou G.; Doukas H.	Energy Research and Social Science	37	2020

8	China's carbon neutrality: Leading global climate governance and green transition	Zhang Y.; Chao Q.; Chen Y.; Zhang J.; Wang M.; Zhang Y.; Yu X.	Chinese Journal of Urban and Environmental Studies	33	2021
9	Exploration of low-cost green transition opportunities for China's power system under dual carbon goals	Yuan K.; Zhang T.; Xie X.; Du S.; Xue X.; Abdul-Manan A.F.N.; Huang Z.	Journal of Cleaner Production	32	2023
10	Macroeconomic exposure of developing economies to the low-carbon transition	Magacho G.; Espagne E.; Godin A.; Mantes A.; Yilmaz D.	World Development	19	2023

Note: TC: total citations

Table 2 presents information regarding the 10 most influential documents. Despite being published recently (2023–2024), the top four most cited documents have already accumulated between 53 and 96 citations, highlighting their significant impact in this research area. In contrast, the 2 earliest published articles titled "Contested energy futures, conflicted rewards? Examining low-carbon transition risks and governance dynamics in China's built environment" (Song et al., 2020b) and "China's carbon neutrality: Leading global climate governance and green transition" (Y. Zhang et al., 2021b) exhibit comparatively lower citation counts. To be specific, the study named "The role of green industrial transformation in mitigating carbon emissions: Exploring the channels of technological innovation and environmental regulation" (Mehmood et al., 2024b) has the highest citations (96), nearly 3 times that of the 2 articles published in earlier periods mentioned above. However, not all recently published studies have demonstrated high academic impact. As illustrated in Table 2, two articles published in 2023- "Macroeconomic exposure of developing economies to the low-carbon transition" (Magacho et al., 2023) and "Exploration of low-cost green transition opportunities for China's power system under dual carbon goals" (Yuan et al., 2023) have received only 19 and 32 citations, ranking 10th and 9th in the table, respectively. Therefore, similar to the scholarly influence of a source, the academic impact of a publication may be determined by other factors rather than solely by its year of publication.

As observed from the top 10 most influential articles, these documents focus mainly on three key topics: carbon policy and governance, innovation for decarbonization, and localized or sector-specific carbon strategies. For instance, documents in the first group concentrate on evaluating the efficacy of specific policies such as carbon emissions trading (Han et al., 2023), macro-level policy and recommend regulatory responses (Magacho et al., 2023) as well as critical objectives, including carbon emission peaking, industrial green transition (Zhou et al., 2022), carbon neutrality (Y. Zhang et al., 2021b) to clarify regulatory models and policy directions aimed at attaining emissions reduction goals. Next, the papers from the second group highlight the impact of digital infrastructure, technological innovation, industrial transformation, green patents, and R&D investment on carbon emission reductions. To be specific, these documents show clear evidence that green innovation, R&D investment (Abbas et al., 2024), and digital infrastructure from big data policy pilots are critical drivers of environmental sustainability and significantly reduce urban carbon emissions in China (Wei et al., 2023). Moreover, the study by Yuan et al. (Yuan et al., 2023) provides a comprehensive techno-economic analysis of decarbonization pathways in China's power sector through 2035 and highlights the necessity of expanding renewable energy capacity. The carbon emission reduction is also shown to operate through three main channels: industrial upgrading, energy efficiency improvement, and enhanced green total factor productivity in manufacturing (Wei et al., 2023). Furthermore, this group topic contains the most influential paper by Mehmood et al. (Mehmood et al., 2024b). This article investigates the impact of GIT on reducing carbon intensity in Pakistan between 1975 and 2020 and explores the relationship between factors such as foreign direct investment (FDI), technological innovation, green industrial transformation, environmental legislation, and research and development (R&D) investment. In Pakistan, green industrial transformation is associated with lower carbon emissions; however, unmanaged technical innovation, R&D investment, and inbound foreign direct investment (FDI) contribute to increased carbon emissions. Although R&D investment contributes to environmental sustainability in China by promoting green technologies, it leads to increased carbon emissions in Pakistan due to this nation's limited clean technology adoption and weaker environmental regulations. This contrast suggests that policy tools such as R&D investment do not produce consistent results among nations, but their efficacy depends on various factors, including technological infrastructure, economic structure, and the alignment between development goals and environmental priorities. Additionally, in the third group, the study by F. Yang et al. (F. Yang et al., 2023) examines the decoupling status of CO_2 emissions and economic growth in Chengdu by analyzing the city's CO_2 emissions from 2009 to 2020, concluding that population and energy intensity are the primary factors influencing Chengdu's CO_2 emissions, with rising energy consumption being the main driver of CO_2 emission growth in the city. In addition, research by Song et al. (Song et al., 2020b) focuses mainly on exploring the development of a green transition pathway for the Chinese building sector, informed by national and local low-carbon policies and strategies, especially in big cities, including Beijing and Shanghai. This paper also simulates the impacts of the policy strategies considered on the low-carbon transition of the Chinese built environment, as well as the extent of their potential negative

consequences.

Building on these three thematic groups, including carbon policy and governance, innovation for decarbonization, and localized or sector-specific carbon strategies, this research suggests several practical implications emerge for policymakers and researchers. To be specific, the evidence from the "carbon policy and governance" strand suggests that governments in developing economies should integrate carbon governance with innovation incentives, as demonstrated by the Chinese case. China's experience illustrates that the integration of carbon pricing mechanisms and emissions trading schemes with coordinated industrial green transition policies can simultaneously strengthen regulatory compliance while promoting technological advancement (Y. Zhang et al., 2021b; Zhou et al., 2022). Besides, the theme of innovation for decarbonization highlights the crucial role of digital infrastructure, R&D investment, and green technologies in accelerating the transition toward carbon neutrality. However, cross-country comparisons, such as the divergent outcomes of R&D investment between China and Pakistan (Mehmood et al., 2024b; Wei et al., 2023), indicate that policy instruments do not operate uniformly but are influenced by local institutional quality, absorptive capacity, and governance effectiveness. Such an outcome implies that governments should design context-specific policy combinations that align environmental priorities with national development goals rather than applying generic policy frameworks. For ASEAN economies, including Vietnam, the findings reinforce the timeliness of advancing regional carbon markets and encouraging knowledge-sharing platforms to reduce transaction costs and enhance market credibility, drawing lessons from the EU ETS while adapting to local political and economic contexts (Vollebergh & Brink, 2020). Simultaneously, the research on localized and sector-specific strategies indicates that macro-level governance must be complemented by sectoral roadmaps designed for high-emission industries, including construction, manufacturing, and energy-intensive sectors (Song et al., 2020b; F. Yang et al., 2023). By embedding just transition measures, such as re-skilling programs and financial support for vulnerable communities, into these strategies, policymakers can mitigate the social risks associated with decarbonization and ensure long-term policy legitimacy. Together, these implications suggest that effective carbon neutrality pathways require a coordinated strategy that integrates governance, innovation, and localized action, with insights from China providing a valuable but non-universal model for developing economies.

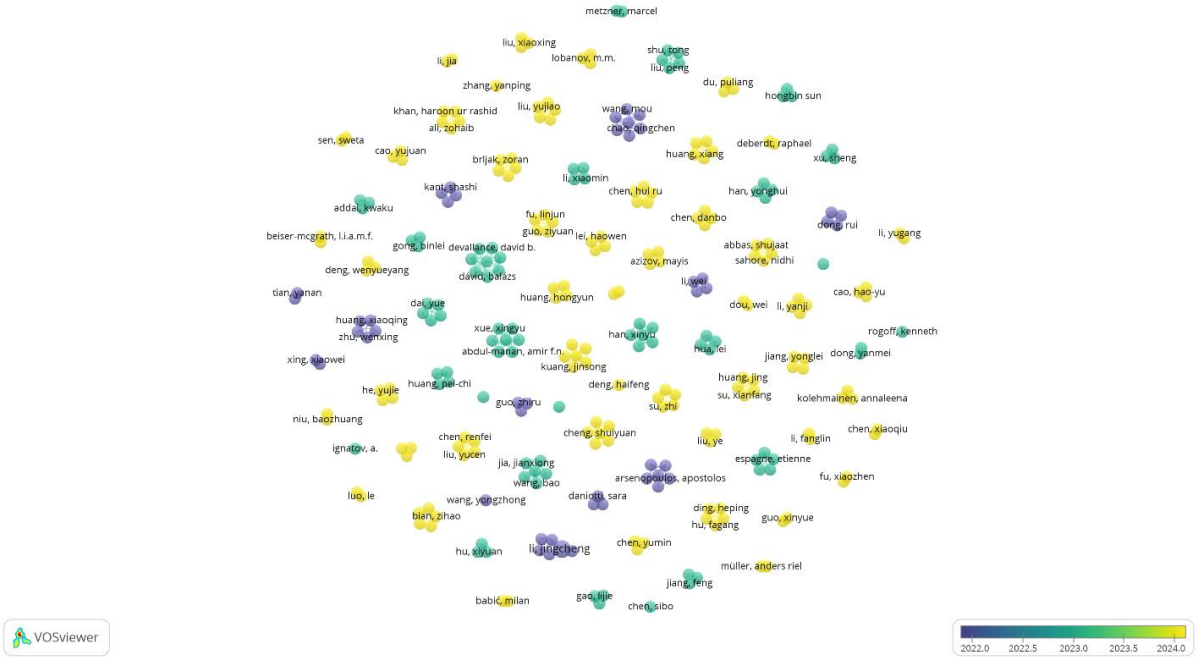


Figure 5: Co-authorship map of carbon emission reduction scholars between 2020 and 2024.

Figure 5 represents different research groups on carbon emission reduction over time. Each circle represents an author. Only 1 of 298 authors possesses 2 articles; no author has 3 or more works, and all other authors have only one. This result indicates that this topic has attracted considerable interest from numerous researchers, with the majority of writers engaging in collaborative research rather than working independently and often forming research groups that include tiny teams of just 2–3 authors. Furthermore, there is worldwide collaboration among scholars from many nations. The temporal density map illustrates the development of research networks across time. The node colors represent the authors, signifying the average publication year of the research publications in which they were involved. The darker blue denotes authors involved in research activities in 2022, green nodes signify authors active from early to mid-2023, and yellow nodes indicate authors who have been actively engaged recently (2024). The map reveals that yellow predominates, indicating that these writers have engaged in substantial recent research activity. The clusters of green emerge with notable frequency, suggesting that 2023 may signify a pivotal moment for advancements in science. The dark green clusters represent pioneering authors who have spearheaded and established the foundational framework in the field of green

transition.

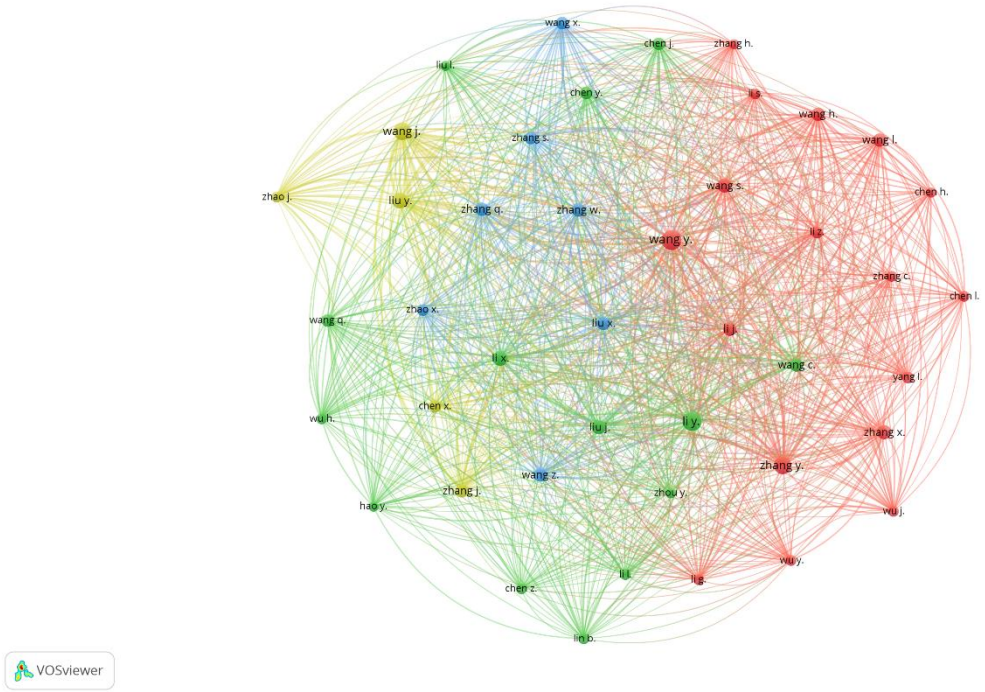


Figure 6: Co-authorship network map of carbon emission reduction scholars between 2020 and 2024.

Additionally, the co-authorship network map (Figure 6) is divided into four clusters, corresponding to four distinct color areas: blue, green, red, and yellow. Four clusters represent four collaborative groups—the groups of authors who frequently collaborate. All authors in these groups have Chinese names, indicating that the research teams are all from China. Furthermore, there is a strong connection among these clusters. The red cluster comprises writers, including Wang Y., Wang S., Zhang Y., Wang Q., and Zhang X., as well as other authors. In addition, the cluster in blue has notable authors, including Zhang W., Liu X., Wang Z., Zhang Q., and others.

Despite its smaller size, this cluster appears to serve a bridging function within the network. The green cluster includes prominent authors such as Li Y., Liu J., Li X., and Wang Q. The yellow-colored cluster includes authors Wang J., Liu Y., Chen X., Zhang J., and Zhao J. Figure 6 shows that the red cluster is the largest and most densely populated collaboration cluster, signifying its position as a robust research network and its pivotal role within the research community on this subject. The collaboration network in this cluster is wide, characterized by strong cooperation and a significant volume of research articles, as indicated by the size of the nodes and the connections among the researchers. Moreover, the second most significant cluster is the green cluster. It is an internally cohesive group, indicating a well-established research team. Notable connections link it to the red and blue clusters, indicating their partial isolation and moderate outward extension. Lastly, the yellow cluster is the smallest group within the co-authorship network. Although there are some external connections with the green and blue clusters, the majority of collaborations are internal, signifying that this group mostly operates within its network.

This network demonstrates that while the research landscape is characterized by clustered collaboration, it is not isolated. Some pivotal individuals are serving as intermediaries, promoting the dissemination of knowledge among groups, such as Wang Y., Liu J., and Chen Y. Our database also reveals that there are 298 authors published in the field of carbon emissions reduction, and all of them have published at least one document and a maximum of two. The most cited author is not the one with the most articles. To be more detailed, Chen H. and Chen J., who had the most citations, had only one article on this research topic, but their work was cited 571 and 789 times, respectively. Concerning prominent authors, there are several authors who exhibit substantial node sizes, indicating their considerable influence in the field. Wang Y. is the author with the highest number of publications and occupies a pivotal position in the network, with 76 citations. Wang C. and Li Y. from the green cluster are close to the center of the red cluster, indicating that these authors have a high level of teamwork.

3.3 Topical trends in the carbon emission reduction knowledge base

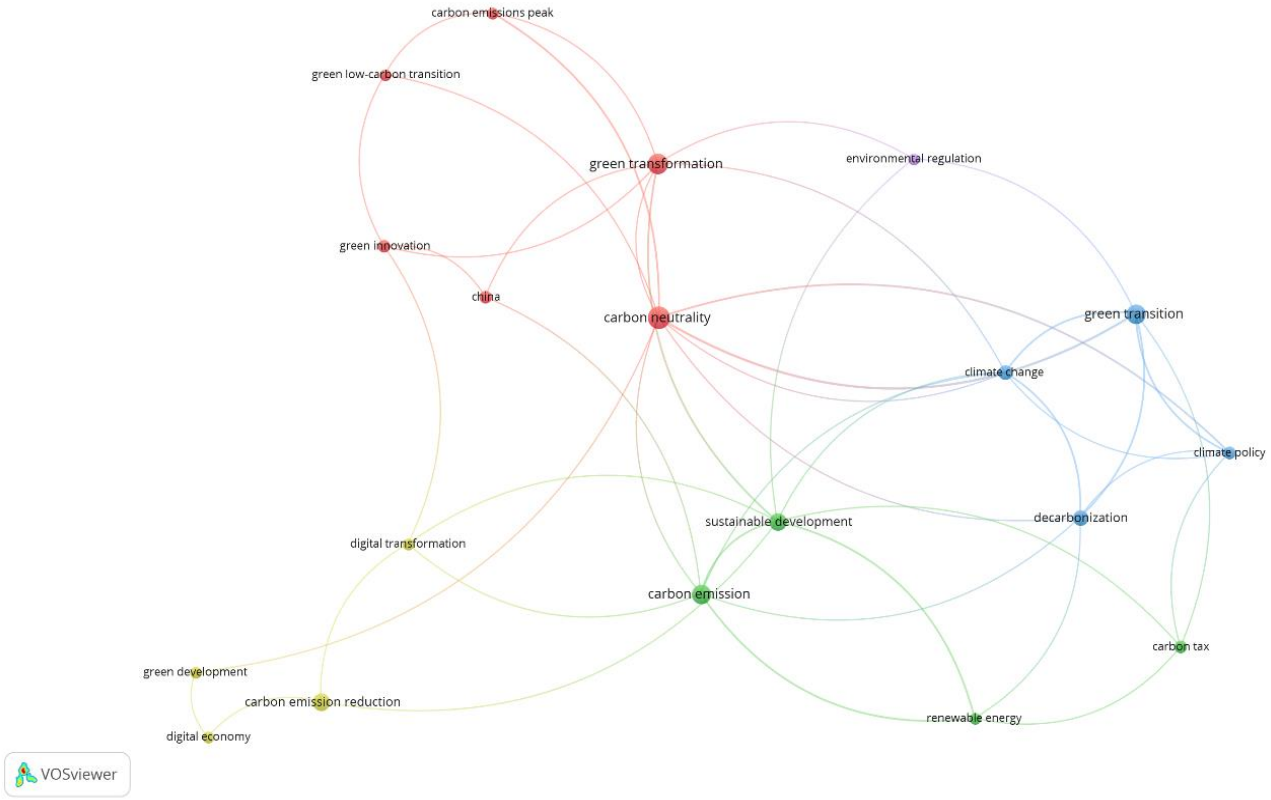


Figure 7: Main driver research in carbon emission reduction based on Co-word analysis, 2020-2024.

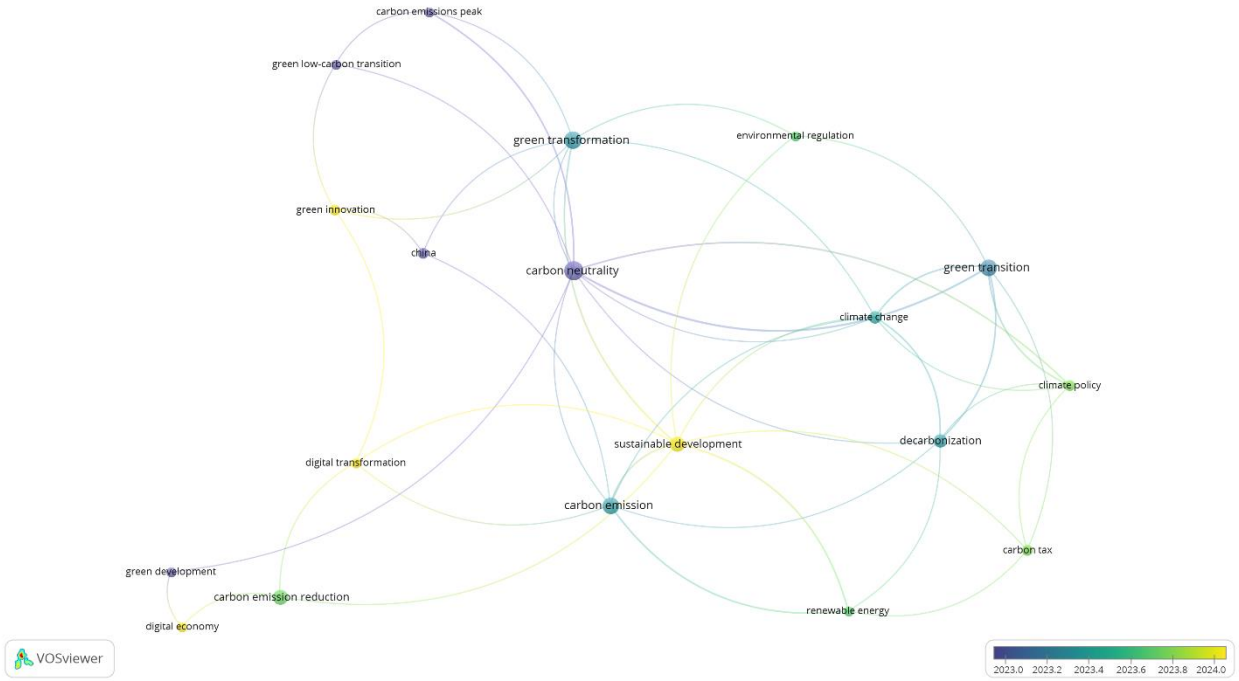


Figure 8: Main driver research in carbon emission reduction based on Co-word analysis, 2020-2024.

The most important topics in carbon emission reduction literature were indicated by analyzing keywords of carbon mitigation documents. Figure 7 represents our co-keyword analysis. In this figure, 19 keywords correspond with 19 nodes, each occurring at least twice, and the size of each node reflects the number of occurrences of the respective keywords in our studied documents, while the widths of the lines connecting different nodes represent the number of co-occurrences of the respective keywords in the same carbon emission reduction documents. Figure 7 also shows 3 groups of clusters featured by five clusters identified from the co-keyword analysis, which reflect 3 topical themes mentioned in the analysis of the top 10 influential documents. Apart from cluster identification, VOSViewer also enables researchers

to identify the recency of topical themes. Temporal co-word analysis in Figure 8 reveals the time when particular topics were at the height of their popularity. Each node on the map represents a keyword, with the size of each node indicating the frequency of the keyword's occurrence and the color of the nodes denoting the average year of the keyword's emergence. The node's purple color signifies keywords associated with topics that emerged in early 2023. Next, the blue and green nodes represent topics of carbon emission reduction in 2023.2 and the second quarter of this year (2023.4-2023.6), respectively. The nodes in yellow represent emergent topics garnering scholarly attention in 2024. All main topics in the field of carbon emission reduction arise over the period of 2023 to 2024, indicating that this research area has garnered significant attention from the academic community recently. As illustrated in Figure 6, while the red cluster includes keywords such as “carbon neutrality” (2023.0), “green transition” (2023.2-2023.4), “carbon emissions peak” (2023.0), “green low-carbon transition” (2023.0), “green innovation” (2024), and “China” (2023.0), the purple cluster contains only “environmental regulation” (2023.6-2023.8). Moreover, the keywords “green transition” (2023.2-2023.4), “climate change” (2023.2-2023.4), “climate policy” (2023.6-2023.8), and “decarbonization” (2023.2-2023.4) are in the blue cluster. The cluster in green has keywords including “carbon emission” (2023.2-2023.4), “renewable energy” (2023.6-2023.8), “sustainable development” (2024), and “carbon tax” (2023.6-2023.8). Other keywords such as “carbon emission reduction” (2023.6-2023.8), “digital transformation” (2024), “digital economy” (2024), and “green development” (2023.2-2023.4) are in the yellow cluster.

In general, the keywords that have received the greatest academic attention recently focus mainly on digital technologies and sustainable environmental policy. Moreover, this study suggests that the subject of "Carbon Policy and Governance" is represented by red, blue, and purple clusters. These clusters primarily concentrate on national strategies and methods for attaining carbon neutrality, especially green transition. Additionally, these clusters signify the role of climate policies and governance mechanisms in facilitating the green transition. This issue is the most influential topic in the research area of carbon emission reduction. The green cluster focuses on "Innovation for Decarbonization" by illustrating the importance of sustainable energy systems and renewable energy in achieving carbon reduction goals. Besides, the yellow cluster’s theme is determined as "localized or sector-specific carbon strategies," which highlights the role of digital transformation and green innovation in supporting carbon emission reduction.

Building on these findings, Figure 8 reveals several underexplored domains that provide potential opportunities for future research. Although sustainable development and renewable energy are well integrated into the carbon neutrality discourse, the connection with digital transformation and the digital economy remains tenuous. This is significant considering the increasing potential of digital technologies such as artificial intelligence (AI), blockchain, the Internet of Things (IoT) to improve carbon monitoring, reporting, optimize industrial energy consumption, and facilitate low-carbon supply chain management (Hong & Xiao, 2024; Kumar Patro et al., 2024). Future studies should explore how digital innovation can accelerate carbon neutrality, providing a framework for the so-called “twin transition” that unites digital and green agendas. In addition, the current literature mostly focuses on technical and policy methodologies, while interdisciplinary perspectives remain underrepresented. Figure 8 also shows limited connections between themes of carbon neutrality and broader socio-economic dimensions such as green finance, organizational behavior, or innovation management. This gap suggests that future research should incorporate financial, social, and behavioral aspects, such as examining the role of green bonds in funding decarbonization, the influence of corporate governance on low-carbon strategies, or behavioral drivers of organizational adoption of green technologies. This endeavor would extend beyond engineering solutions to address the systemic transformations required for carbon neutrality. Another observation is the concentration on China as a national reference point, reflecting the nation's substantial commitments to carbon peaking and neutrality. However, this focus underscores a geographic imbalance, since the map indicates minimal representation of other developing economies, especially in Vietnam and ASEAN countries. Besides, while the European Union Emissions Trading System (EU ETS) has been widely studied**,** evidence from Southeast Asia is limited. Considering Vietnam’s recent pilot implementation of a domestic carbon credit exchange (*Pilot the Carbon Credit Exchange from 2025*, n.d.)**,** comparative studies on the design, challenges, and opportunities of carbon pricing schemes in ASEAN could provide timely and policy-relevant insights. Moreover, although the connection between sustainable development and carbon neutrality is evident in the literature, more systematic studies are required to evaluate how Sustainable Development Goals (SDGs) can be aligned with industrial decarbonization strategies. Research could examine how enterprises in high-emission sectors, including manufacturing, construction and energy-intensive industries, integrate SDGs into their decarbonization strategies, and how these synergies might enhance both environmental and economic resilience (Onyinyechukwu Chidolue et al., 2024; Rodaro et al., 2025).

4. CONCLUSION

This research used bibliometric methods to provide a comprehensive analysis of mitigating carbon in the context of green transition at a global scale. The analysis of 87 Scopus-indexed articles published between 2020 and 2024 revealed trends in annual publication rates. Regarding location, China holds the most dominant position, reflecting its strong dedication and strategic emphasis on reducing carbon emissions as a key national research objective. The United States follows as the second-largest contributor and one of the initial participants in this topic. This study also highlights the most prominent research topics pursued by authors in China, which include "environmental regulation and policy related to carbon emissions, as well as the factors that motivate firms to undergo green transition." Researchers can use this result to guide

future research topics on carbon emission reduction. In conclusion, China is taking steps to combine policy pressure with investments in research on endogenous dynamics within enterprises, indicating a shift from administrative management to encouraging innovation and flexible adaptation in the green transition. The striking disparity correlates with the rising number of publications on carbon policy and green transition, indicating that China is gradually shaping its leadership role in global environmental issues. Although Chen H. and Chen Y. are the most influential authors, each has only one article. Besides, while Wang Y. is the author with the highest number of publications, Wang C. and Li Y. have a high level of teamwork. "Journal of Cleaner Production" is the most influential journal in its field, surpassing all other journals in terms of effectiveness. "Sustainability (Switzerland)" and "Environment, Development and Sustainability" are the most productive journals. Thus, authors need to pay attention to these journals when researching carbon emission reduction. In addition, there are three main research themes: "Carbon Policy and Governance," "Innovation for Decarbonization," and "Localized or Sector-Specific Carbon Strategies." Among the research themes on carbon emission reduction, “Carbon Policy and Governance” emerges as the most impactful topic. It is evidenced by the results of co-word analysis, the analysis of the most influential journals and documents. This research suggests several key policy directions for advancing carbon emission reduction. Governments should integrate digital transformation with green strategies by utilizing technologies such as AI, blockchain, and IoT to improve carbon monitoring, enhance industrial efficiency, and enable low-carbon supply chains. Besides, policy frameworks should extend beyond technical approaches to integrate financial, social, and behavioral dimensions, such as mobilizing green finance, enhancing corporate governance, and promoting the adoption of sustainable technologies. Comparative studies and policy experimentation are especially needed in developing economies, including Vietnam and ASEAN countries, where the formulation of carbon pricing and emissions trading frameworks can benefit from insights gained from the EU ETS while being adapted to local contexts. Moreover, policymakers are encouraged to integrate market-based mechanisms with innovation incentives, ensuring that carbon governance is closely linked with industrial transformation policies. This requires context-specific policy mixes linked with national development goals, rather than the adoption of generic frameworks. These ideas emphasize the significance of coordinated governance, digital and technology innovation, financial and social integration, and sector-specific policies in formulating successful carbon neutrality paths. The limitation of this research is that its database consists of Scopus-indexed English documents. While this selection criterion is convenient and reproducible, it also induces systematic biases that can significantly impact both the substantive conclusions about global research on carbon-emission reduction and the descriptive outcomes, including counts by country, institution, and topic. Amano et al. (Amano et al., 2016) indicated that 35.6% of conservation articles published in 2014 were in non-English languages, implying that searches limited to English may exclude a significant amount of domain-relevant knowledge. In this study, such omissions can skew topic frequencies through overrepresenting themes predominantly published in English and diminishing the assessment of international collaboration by excluding non-English documents. Furthermore, reliance only on English articles on Scopus likely underestimates domestic (Chinese-language) scholarship and policy reports that analyze regional pilot programs, municipal ETS pilots, eco-compensation schemes, and industry-level case studies. In addition, indexing bias may compress the apparent diversity of institutional contributors by excluding numerous university presses or society journals that publish locally salient research. Consequently, this approach leads to the results presented here, which, at present, do not fully capture the complete picture of this research area.

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