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Bibliometric analysis of carbon emissions in construction industry documents: implications for sustainable development

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Abstract

Background: Global temperatures may rise by 4–8 °C by the century's end due to greenhouse gas emissions, underscoring the need to reduce carbon emissions. Given the construction industry's 39% share of global CO_2 emissions, this study uses bibliometric analysis to evaluate existing research, identify gaps and trends, and support future studies and policies that promote low-carbon, sustainable development in the construction sector.

Methods: The analysis covers all documents on carbon emissions indexed in the Web of Science (WoS) Core Collection from 2015 to 2024, examining aspects such as document type, year of publication, WoS Core Collection subject classification, top publications, co-authors, subject classification via coupling and word co-occurrence networks, and citations.

Results: Publications on carbon emissions in the construction industry have increased rapidly, peaking in 2023. Most studies are articles, with China leading in output. The Chinese Academy of Sciences is the leading institution. Research mainly falls under "Green & Sustainable Science & Technology," with the *Journal of Cleaner Production* publishing the most articles. The dominant theme is "urbanization and carbon emission."

Conclusion: The research highlights a growing global emphasis on reducing carbon emissions in the construction sector, primarily driven by related industrial activities such as fossil fuel use for energy, transportation, manufacturing, and heating. Despite increased attention to sustainability, key gaps persist across energy management, life-cycle assessment, carbon capture, and socio-economic policy impacts. These gaps may be due to the complex, interdisciplinary nature of energy-related topics, making them harder to address comprehensively.

Keywords: Carbon emissions, Construction industry, Environment, Bibliometrics, Global warming

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Introduction

The rise in average air temperature due to increased greenhouse gas concentrations is expected to continue, with global temperatures predicted to rise by 4–8 °C by the end of the 21st century (1). Carbon dioxide, the most significant greenhouse gas, directly contributes to this warming (2). Reducing carbon emissions is essential to controlling climate change, as temperature reduction goals are tied to emission-reduction targets. Since 2007, carbon emissions have increased from 21 to 38 gigatons, an 80% rise, with 2019 emissions nearly 19 times higher than in 1900 (3). According to the latest data, global GHG emissions in 2023 reached 53.0 Gt CO_2 eq. The 2023 data represent the highest level recorded, with an increase of 1.9% or 994 Mt CO_2 eq compared to 2022 levels (4). This issue has also affected the economic conditions and production of countries, with the total cost of climate change resulting from CO_2 emissions projected to equal a 5% reduction in global GDP annually, potentially rising to 20% without urgent action (5). Various human activities, including construction, agriculture, industry, waste disposal, and deforestation, have significantly increased greenhouse gas (GHG) emissions (6). The construction industry is a significant emitter, responsible for over one-third of greenhouse gas emissions, with impacts from energy use, material processing, landfilling, water consumption, and land use (7). The global construction industry is a major contributor to carbon emissions, accounting for 39% of energy and process-related CO_2 emissions (8). A significant portion comes from embodied carbon generated during the extraction, processing, transportation, and installation of materials

such as cement and steel. The industry's heavy reliance on energy-intensive materials and fossil fuels makes it a key driver of climate change.

High greenhouse gas (GHG) emissions present serious environmental and socio-economic risks, contributing to global warming, extreme weather events, and health issues, such as respiratory diseases (9). These emissions are primarily concentrated in a few high-emission countries—including the United States, China, Russia, India, Japan, Germany, France, and South Korea—which together account for over two-thirds of global CO_2 emissions (10,11). The primary drivers of these emissions are industry and the use of fossil fuels, including coal, oil, and natural gas, for energy transportation, manufacturing, and heating (11). Additionally, emissions are exacerbated by deforestation, industrial agriculture, and the material-intensive practices of sectors like construction. Industrialized nations, in particular, rely heavily on carbon-intensive activities to sustain growth and urban development. To reduce environmental impacts, especially in sectors such as construction, it is essential to adopt sustainable practices, including low-carbon materials, energy-efficient designs, carbon capture technologies, and circular economy strategies (12). Addressing emissions in these major contributing countries is critical to achieving global climate goals. Efforts to reduce emissions began in the 1990s, leading to the 2015 Paris Agreement, which aims to limit global temperature rise to 2 °C above pre-industrial levels (13,14). Addressing carbon emissions remains a crucial global challenge, requiring effective climate policies and efforts towards sustainability and health (15,16).

Recently, addressing climate change by enhancing environmental sustainability and community health through reducing greenhouse gas emissions and promoting low-carbon practices has become a top priority (1). This issue has drawn significant interest from researchers and policymakers, leading to a surge in research on carbon emissions. Despite the rich data available, some areas remain underexplored. Early research on carbon emissions dates back to 1981, and interest has grown as global warming intensifies, making it a central topic in sustainability studies (17).

Carbon emission research is divided into industrial and regional categories. Industrial research focuses on sources of carbon emissions, carbon footprints, sectoral emissions, and the link between economic status and emissions (18). Regional research often targets specific areas, with China, the largest emitter, being a primary focus, especially in its industrial sector (19). A review by Li and Zhao in the WoS Core Collection database highlighted a lack of studies on developing countries, prompting increased global attention to these regions (20). As of 2019, China, the US, and the UK lead in carbon emissions research publications, with significant contributions from institutions such as the Chinese Academy of Sciences and Tsinghua University (17).

International collaboration in carbon emissions research has increased, enhancing the quality of articles through the sharing of ideas and resources. China, India, and Brazil are leading in this cooperative effort, particularly in environmental science, ecology, engineering, and health (20). Research often spans multiple disciplines, with a notable focus on carbon emissions in transportation, including low-carbon technologies and green supply-chain management (21). Researchers from the US, China, and the UK, with notable contributions from Tsinghua University and Dr He, have published influential work in this area (22).

The construction industry is a significant focus in carbon emissions research, increasingly adopting interdisciplinary approaches that incorporate urban behaviors and digital technologies (22). China, the largest emitter in this sector, has received significant research attention (23). Chuai et al. identified construction as a major emitter among seven upstream industry groups (24), with potential reductions in this sector predicted to be substantial (25). Research is particularly focused on construction methods, with Chen et al. analyzing emissions from prefabricated structures and highlighting the need for greater efforts to reduce them (26). Recent studies have also examined energy efficiency, life-cycle analysis, and the environmental performance of materials, though these areas remain underexplored (27). Studies have highlighted the importance of building materials in the design, construction, and operation of energy-efficient buildings (28). Differences persist in evaluating the life-cycle carbon emissions of construction materials (29).

In bibliographic studies of carbon emissions, thematic analysis often uses bibliographic coupling and word co-occurrence networks. Bibliographic coupling, introduced by Kessler in 1963 (30) and later expanded by Small and Marshakova, groups documents based on shared bibliographic sources (31,32). This method has highlighted the interdisciplinary nature of carbon emissions research, linking it with politics, economics, and social issues. A 2021 study identified key research clusters, including energy, climate, and technology policy (31).

Word co-occurrence networks analysis, introduced by Callon et al in 1991, maps relationships between ideas by analyzing keyword frequencies in documents. Callon's 1986 book "Mapping the Dynamics of Science and Technology" is foundational in this field. The technique has since gained prominence for examining conceptual networks across various scientific areas, including biology (32), creativity (33), bioinformatics (34), robotic technology (35), scientometrics (36), and the environment (37). It is valuable for creating scientific maps, clustering subject areas, and conducting analytical work (38). The method has been widely used in environmental studies,

particularly in carbon emissions research. Udara Willhelm Abeydeera et al. found that from 1999 to 2010, "climate change" was the most frequently used term in carbon emissions literature, followed by "carbon footprint," "CO_2 emission," "greenhouse gases," "sustainability," "energy," "China," and "life cycle assessment" (17).

This study leverages advanced bibliometric methods—coupling network analysis, word co-occurrence analysis, and citation analysis—with tools such as OpenRefine and Gephi to provide deeper insights into carbon emissions research in the construction sector. Unlike traditional literature reviews, these methods reveal hidden research patterns, thematic structures, and intellectual connections, highlighting underexplored areas and emerging trends. Citation analysis identifies influential studies and research hubs, while visualization tools enhance data interpretation. By systematically mapping the field's evolution, this study addresses gaps in previous research, providing a more objective, data-driven understanding to inform future investigations and policy decisions. It will analyze trends in annual carbon emissions, key thematic areas, geographic and institutional contributions, leading authors and universities, and citation patterns within the construction sector, identifying the most under-researched topics in recent publications. The study's objectives are to evaluate the current state of research on environmental sustainability and carbon emissions in construction and to propose future research directions. Key questions include:

1. What types of documents are most commonly published on carbon emissions in the construction industry? In which years have these documents been most prevalent? Under which WoS Core Collection subject classifications do these documents fall, and in which journals are they published?

2. Which institutions and researchers have produced the most publications on carbon emissions in the construction industry?

3. What specific areas related to carbon emissions and the construction sector are covered by these publications?

4. What is the citation impact of documents published on carbon emissions in the construction industry, and which WoS Core Collection subject classifications contain the most cited documents?

The study aims to map the scientific landscape of carbon emissions research in construction and identify key trends and influential contributions.

Materials and Methods

This research utilized a bibliometric technique, following NIH Library guidelines (39), to analyze 3128 documents on "carbon emissions" published by Elsevier from 2015 to February 2024, indexed in the WoS Core Collection. This reputable database, known for its stringent indexing standards and for containing over 80 million documents, was selected for its comprehensive coverage of high-impact, peer-reviewed journals, ensuring the inclusion of authoritative research. However, WoS has a strong focus on English-language publications, which may underrepresent research from non-English-speaking regions. Additionally, it predominantly indexes high-standard journals, potentially biasing the representation of research from well-funded institutions and limiting the inclusion of studies from developing countries. This study acknowledges these limitations and remains aware of potential gaps in global perspectives on carbon emissions research.

The study applied specific inclusion and exclusion criteria to refine the dataset. Only peer-reviewed journal articles were included, while conference proceedings, book chapters, and non-peer-reviewed sources were excluded to ensure the reliability of the analysis. Additionally, the search was restricted to English-language publications to maintain consistency in text-mining processes and thematic analysis. These criteria were designed to focus on high-impact and widely accessible research within the field. The increased focus on carbon emissions since the Paris Agreement in 2015 is reflected in the rise of related research. Previous reviews covered up to 2015 (20); therefore, this study spans 2015 to 2024 to illustrate the field's intellectual structure and progress.

In February 2024, documents were identified by searching for the term "carbon emissions" in titles and author keywords. The metadata was then downloaded, and the search results were imported into the InCites database for citation analysis. To filter construction-related documents, relevant keywords included construction, building, infrastructure, sustainable construction, architecture, urban development, structural engineering, civil engineering, green building, embodied carbon, and materials science. Further data filtering was performed in Excel, chosen for its capabilities to sort, filter, and manage large datasets based on titles, keywords, and abstracts. Non-English articles were excluded based on language classification. While Excel excels at data organization, filtering, and trend analysis via pivot tables, it has limitations in scalability, automation, and advanced text analysis, making it less precise than specialized bibliometric tools.

The study began by standardizing author and institution names in the Web of Science (WoS) data using OpenRefine (version 3.4.1). This process involved resolving variations in spelling, initials, abbreviations, and different naming conventions, such as synonyms and plural forms, using OpenRefine's clustering features. Collaboration analysis was performed using Sci2 (version 1.3.0), which processed co-authorship, bibliographic coupling, and co-occurrence relationships, and the results were visualized with Gephi (version 0.10.1). Final network graphics were edited with Inkscape software (version 0.92.3), adding image guides

to improve clarity and ease of interpretation. Figure 1 illustrates the flowchart outlining the research steps.

The analysis focused on creating word co-occurrence networks by standardizing words and setting a minimum co-occurrence frequency of five times across the dataset. Bibliographic coupling was used to identify closely related documents based on shared references (at least two shared references), with distance representing the strength of shared citations. Co-authorship networks were built to explore collaboration patterns among authors, requiring at least three shared documents per author. Lastly, the percentile-rank distribution categorized documents by citation impact, highlighting high-impact publications and enabling analysis of variations in citation patterns across the dataset.

Results

First question: Figure 2 classifies the studied documents by document type, year of publication, publication name, and WoS subject category.

What types of documents are most commonly published on carbon emissions in the construction industry? In the WoS database, documents are categorized by their characteristics. Figure 2A shows that of the 3128 documents studied, 2933 (about 94%) are articles (Figure 2).

In which years have these documents been most prevalent? Figure 2B shows that the number of documents on carbon emissions has increased steadily since 2015, with a significant surge in 2022 and 2023. This trend reflects growing global interest in the topic (Figure 2). In addition, a comparison of the total number of articles on carbon emissions with those assigned to the construction industry is shown in Figure S1 (Supplementary File 1). The importance of this topic lies in its ability to show the percentage of construction industry documents relative to the total number of documents on carbon emissions.

Under which WoS Core Collection subject classifications do these documents fall, and in which journals are they published?

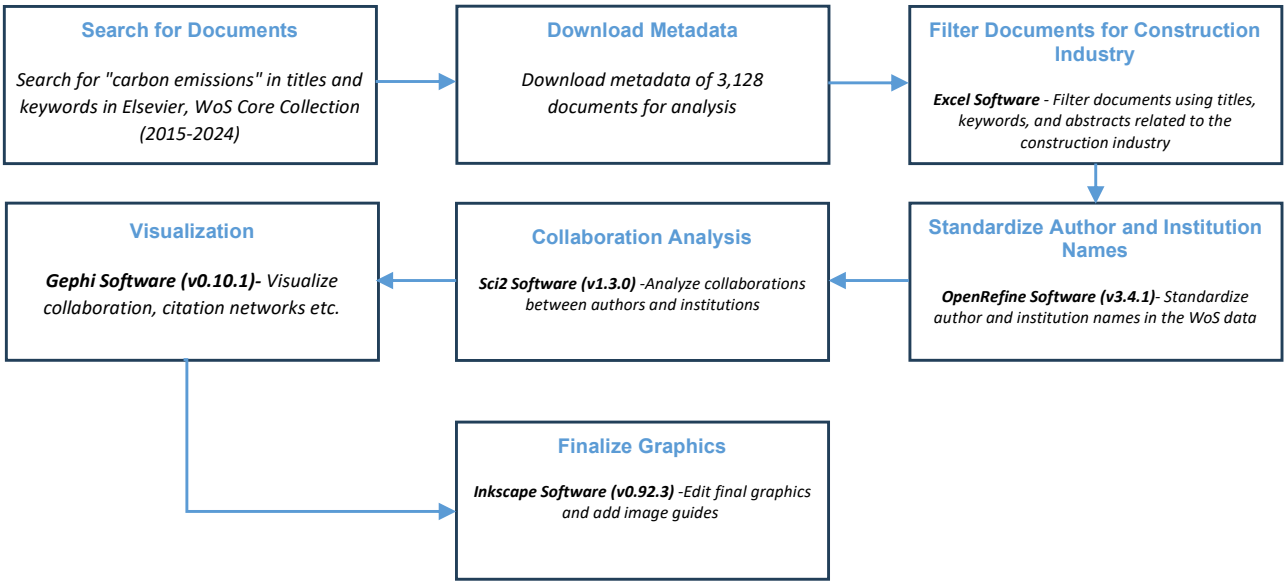

Figure 1. Flowchart of research steps

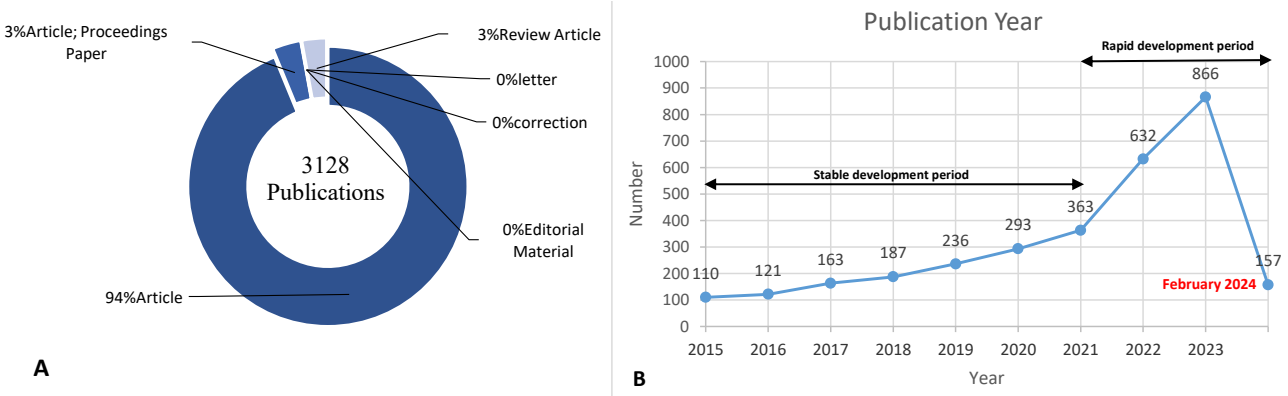

Figure 2. General document analysis of carbon emissions in the construction industry. (A) Document classification by document type. (B) Document classification in the carbon emissions field by publication year

The WoS database categorizes documents thematically by the journals in which they are published, often assigning each document to multiple subject classes. In the construction sector, prominent categories include "Green & Sustainable Science & Technology; Engineering, Environmental; Environmental Sciences" (193 documents), followed by "Construction & Building Technology; Green & Sustainable Science & Technology; Energy & Fuels" (46 documents), and "Energy & Fuels; Engineering, Chemical" (44 documents). The category with the fewest publications related to construction is "Thermodynamics; Energy & Fuels" (29 documents) among the top ten categories (Figure 3).

Figure 3B shows the top ten journals by publication volume on carbon emissions in the construction industry, highlighting the dominance of the "Journal of Cleaner Production," "Sustainable Cities and Society," and "Science of the Total Environment." Figure S2 compares construction-related carbon emissions articles with the total number of carbon emissions articles in leading journals for carbon emissions publications, revealing that less than 25% of these top journal articles address construction issues. This insight helps researchers identify key journals and select suitable venues for their work (Supplementary File 1).

Second question: This section uses co-authorship networks to illustrate collaborations among institutions and authors, highlighting their joint contributions. This information helps authors, research institutions, and universities identify scientific peers in specific fields.

Co-authorship between institutions

In the survey of scientific institutions working in the field of carbon emissions in the construction industry, the Chinese Academy of Sciences, Chongqing University, and Tsinghua University lead in research in this field (Figure S3). Figure S4 shows that the Chinese Academy of Sciences and Tsinghua University account for approximately 28% and 34% of the top articles, respectively, highlighting their significant focus on this area (Supplementary File 1). Despite a high volume of research on carbon emissions, Xiamen University has published fewer documents on the construction sector. Figure 4 depicts a co-authorship network among institutions from 2015 to 2024, with institution size representing publication volume and line thickness indicating collaboration levels. The Chinese Academy of Sciences and Tsinghua University lead in collaboration, with notable cooperation from Peking University, Beijing Institute of Technology, and Tsinghua University.

The data in these figures were collected through a systematic search of organizational affiliations reported by authors in WoS documents. To ensure consistency and accuracy, institution names were standardized using OpenRefine, reducing discrepancies and enhancing the reliability of the research results.

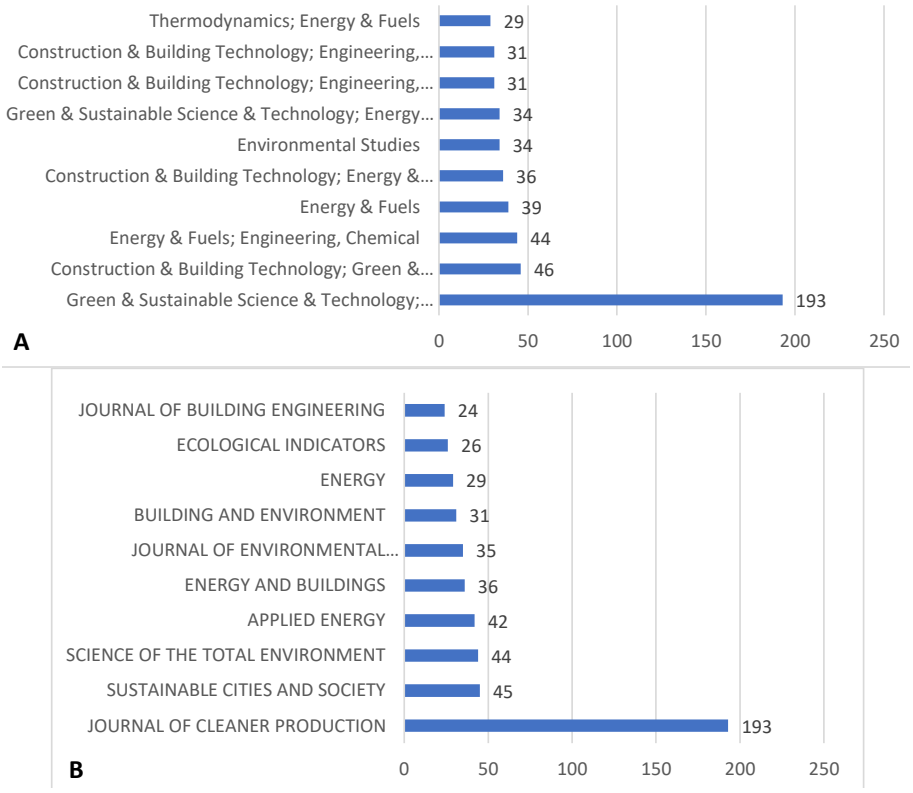

Figure 3. Document analysis of carbon emissions in the construction industry by the top ten (A) WoS categories and (B) publication names

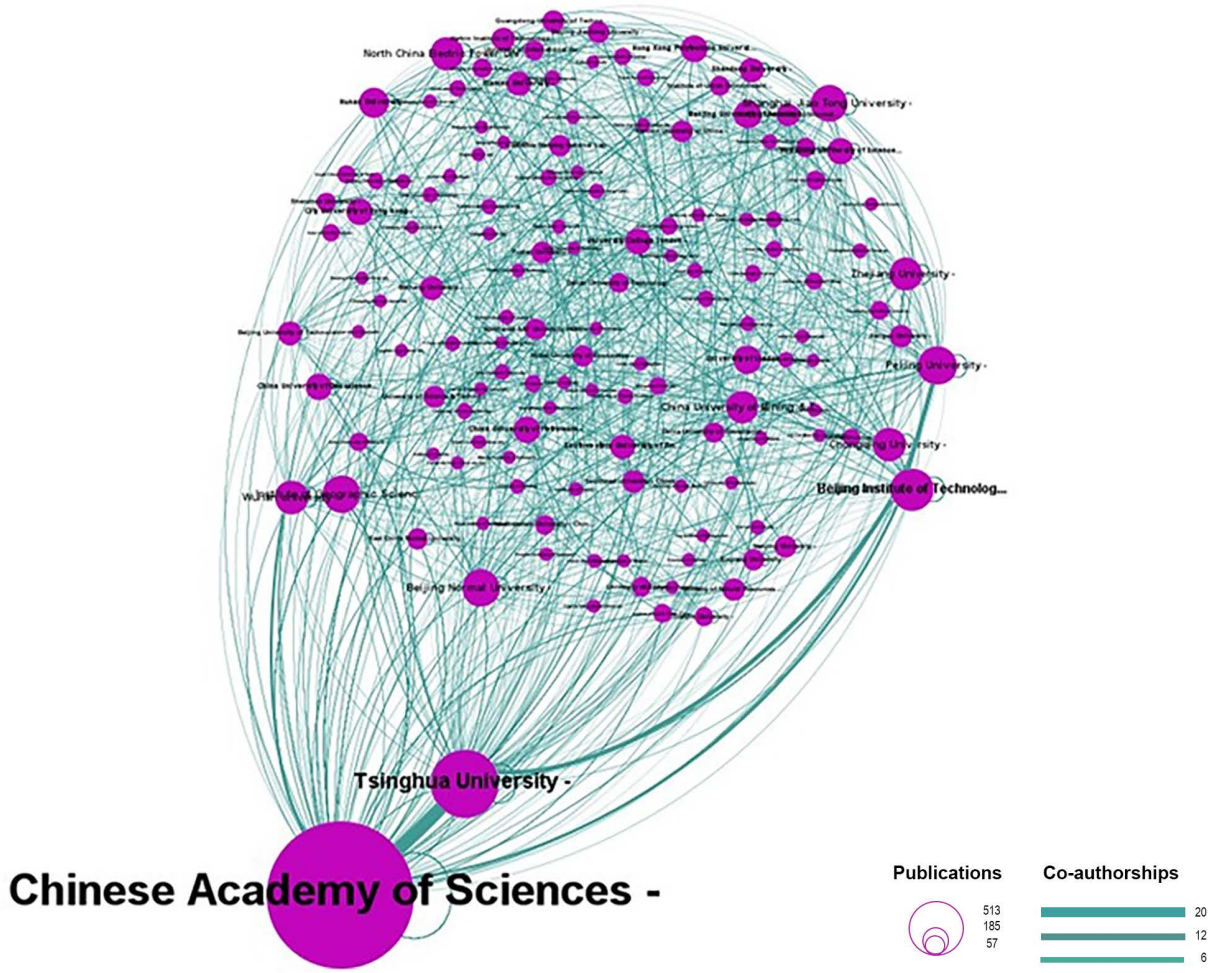

Figure 4. Inter-institutional co-authorship networks for carbon emissions in construction documents

Co-authorship between individual authors

Figure 5 shows the top ten authors in carbon emissions research within the construction industry since 2015. Cai Weiguang and Chen Bin, followed by Zhang Xiaocun, are identified as the most prolific authors. The figure highlights the dominant presence of Chinese authors in this research area. Figure 6 shows an individual-level co-authorship network in carbon emissions research from 2015 to 2024, created using Sci2 and Gephi software. The size of authors' names represents their publication count, while line thickness and colour indicate collaboration levels. Authors with at least three articles in this field are included. Wang Qiang and Li Rongrong have the highest number of collaborations, co-authoring 19 documents. The network highlights extensive author collaboration, which is crucial for achieving significant research outcomes. Author names were standardized using OpenRefine to ensure data accuracy.

Third question: Thematic analysis is a qualitative method used to identify recurring themes and patterns in data. In this study, documents were analyzed and categorized using two techniques: (1) bibliographic coupling networks and (2) word co-occurrence networks.

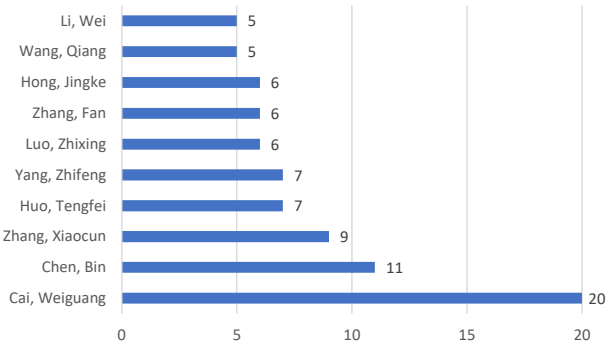

Figure 5. Carbon emissions in the construction industry: distribution among the top ten authors

Bibliographic coupling networks

In this section, the bibliographic coupling technique is used for thematic analysis of publications. Figure 7A displays the thematic map and bibliographic coupling networks for 2472 of the 3128 documents analyzed. Created with Sci2 and Gephi, the map shows documents

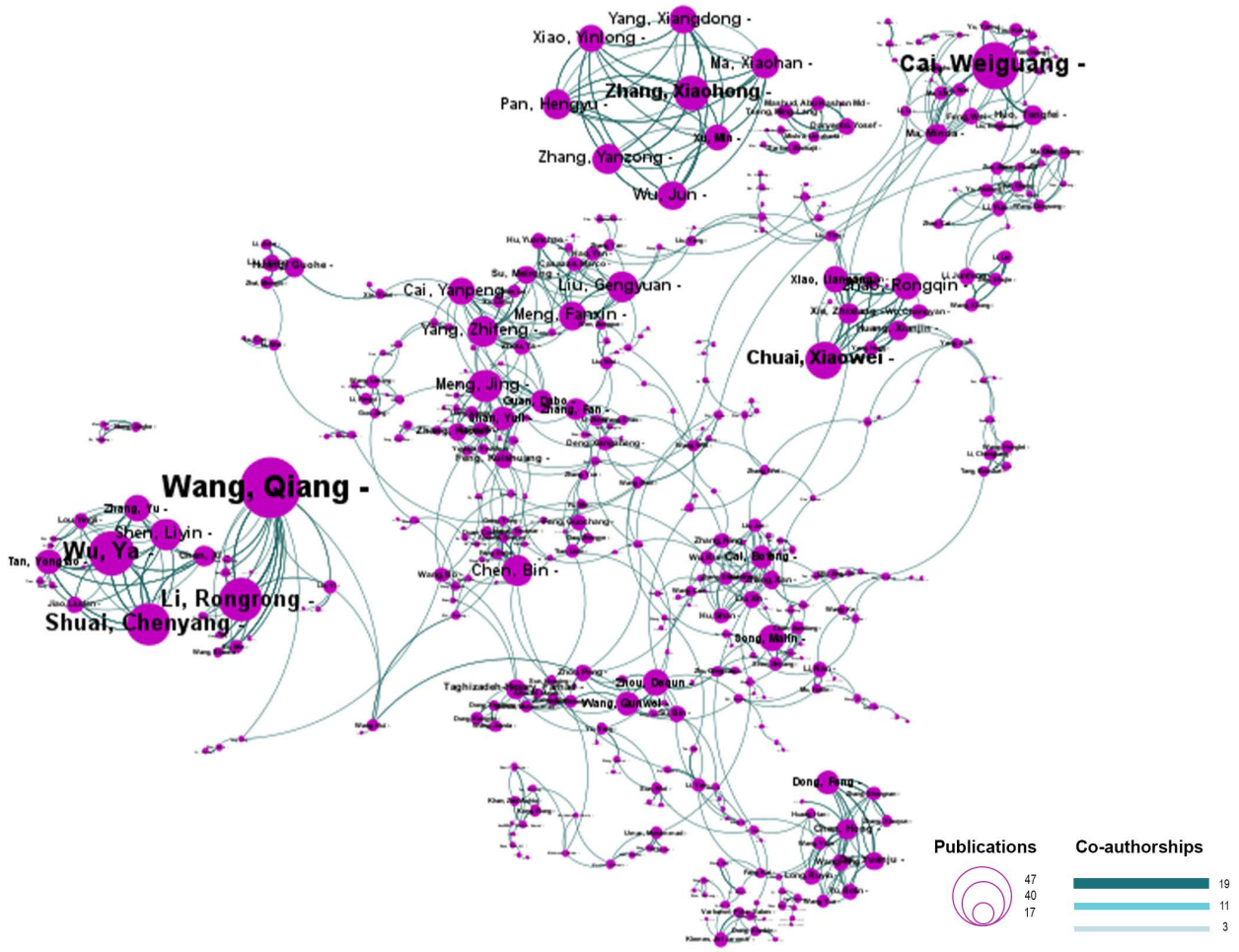

Figure 6. Co-authorship network among individual authors

with at least two standard references, focusing on the most significant connected component for visual clarity.

The figure shows 16 subject classifications in different colors. Nodes represent documents, with size indicating citation count, and color representing the subject class. Subject classes are named based on title and abstract analysis, and the modularity algorithm in Gephi determines their classification. This algorithm identifies closely connected nodes, and shorter distances between subject categories indicate stronger connections. Subject categories are presented in Figure 7.

Figure 7B shows thematic classifications and the number of documents in each category, while Figure 7C displays the number of documents per category by publication year. About 14% (396 out of 2,472) of the documents relate to urbanization and carbon emissions. This picture shows an annual increase in publications in this category, and 2023 had the highest number, about 38% of the total (152 out of 396). The graphs reveal rapid growth in articles on urbanization and carbon emissions, sustainable development policies, balancing emission reduction with economic growth, and carbon-reduction solutions across various industries over the past two years. However, topics such as the impact of technology on emission performance have grown more gradually, while publications on optimizing and regenerative energy systems have declined recently.

Word co-occurrence networks

Figure 8 illustrates the word co-occurrence network method used for thematic analysis. Nodes represent frequently used words from the documents, with line thickness indicating co-occurrence frequency. Node size reflects the number of associated documents, and color denotes subject categories. The modularity algorithm in Gephi groups words based on their relationships. This method identified six subject categories, named by analyzing and summarizing the vocabulary in each category, as shown in Figure 8.

Fourth question: Citation review analyzes citation frequency, patterns, and charts to identify the most important documents in a collection. This section focuses on the citation impact of the studied documents. Because at least 2 years must have passed since a document's publication for practical citation analysis, results should account for this timing and the publication cutoff of

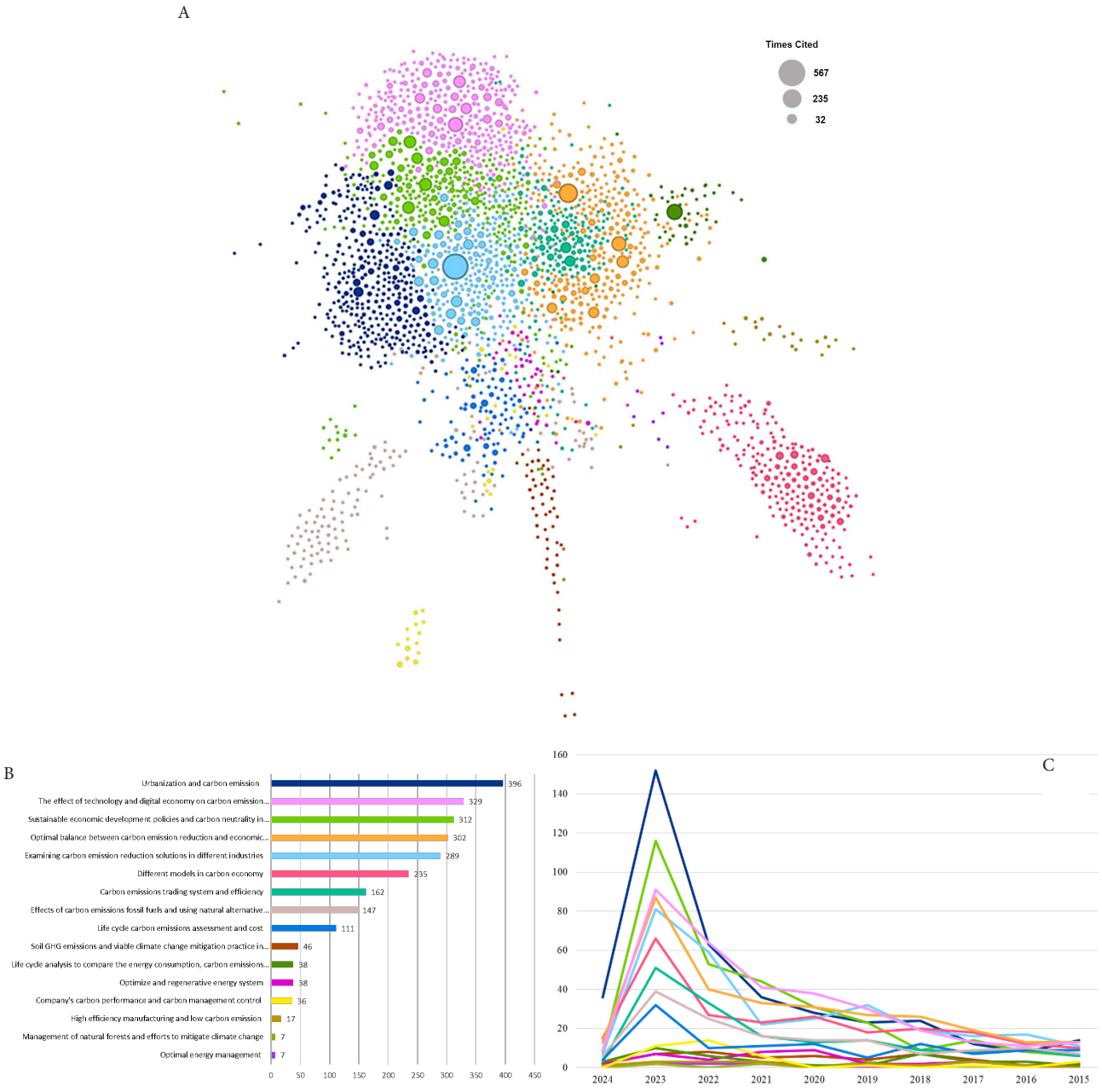

Figure 7. Thematic classification of carbon emissions documents, 2015–2024. (A) Thematic map, (B) document distribution by thematic classification, and (C) document distribution by publication year

February 2024. Note that the citation data comes from InCites and may differ slightly from previous document counts.

Basic indicators of bibliography

Basic bibliometric indicators offer quantitative data for assessing research quality, relevance, and impact. They help researchers evaluate publication visibility, make informed submission decisions, monitor article impact, and identify collaboration opportunities. Table 1 provides these bibliometric indices for all documents studied in the field of carbon emissions in the construction industry.

Table 1 shows that the studied documents have a total of 27,551 citations, with an average of about 33.07 citations per document and a median of 15. Approximately 94.95% of the documents were published in Q1 journals. Additionally, around 9.10% of the documents have received enough citations to be in the top 1% of all carbon emissions research documents during the specified period.

Percentile rank distribution

Percentiles in statistics indicate the value below which a given percentage of observations fall. For example, the 25th percentile is the value below which 25% of observations lie. Figure 9 categorizes documents into four percentile rank groups: top 1%, top 25%, top 50%, and below 50%, based on their percentile in the subject area

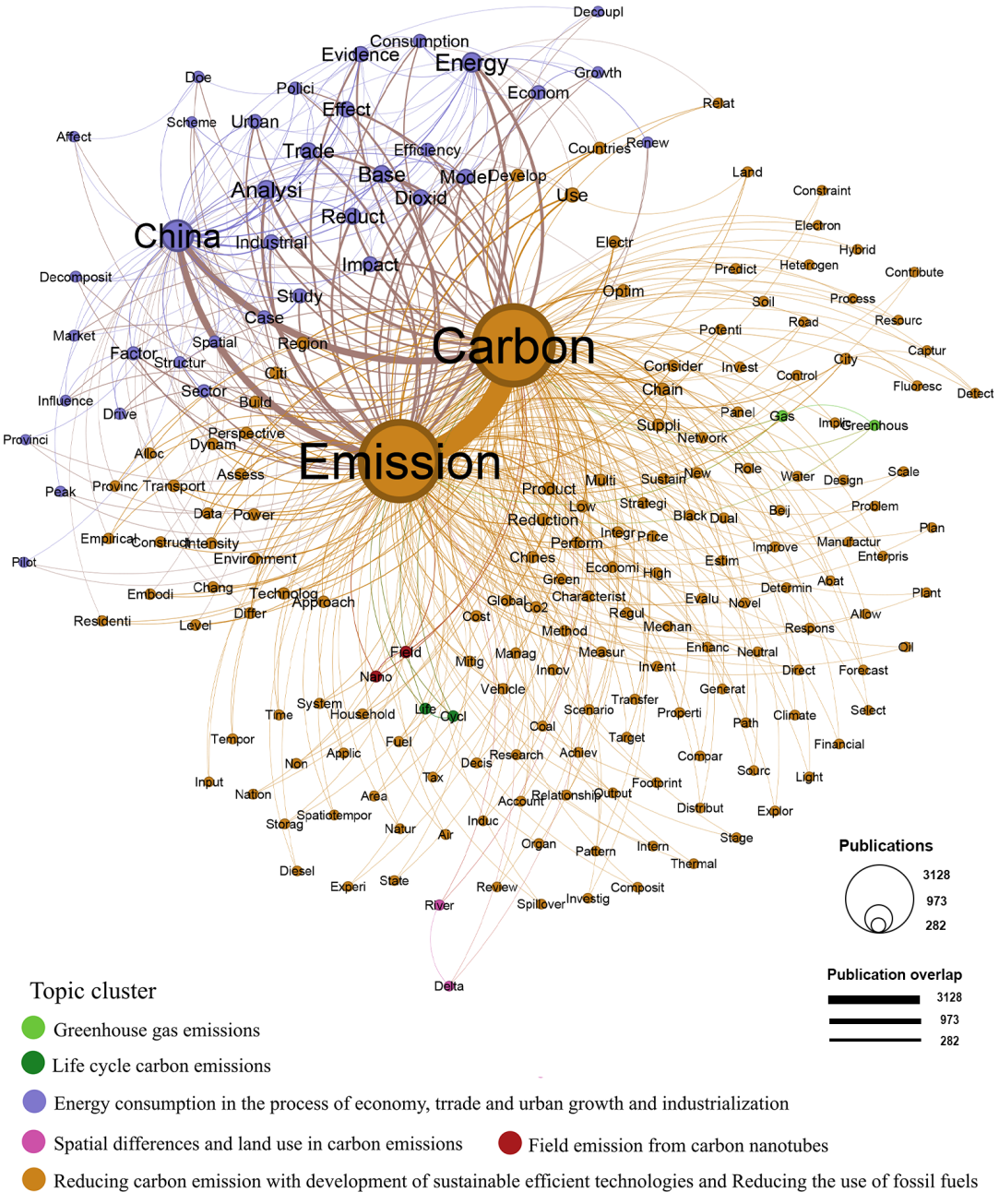

Figure 8. Thematic modeling of carbon emissions documents using the word co-occurrence networks method

from InCites, showing that most documents on carbon emissions in the construction field are in the top 50% for citations.

Percentile rank distribution by WoS subject categories and partner institutions

Figure S5A shows the distribution of documents across various WoS subject categories and percentile rank groups, focusing on the top ten subject categories by publication volume. It highlights that the categories "Construction & Building Technology; Green & Sustainable Science & Technology; Energy & Fuels," "Construction & Building Technology; Energy & Fuels; Engineering, Civil," and "Energy & Fuels" rank in the top 1% for citations related to carbon emissions in construction.

Figure S5B illustrates the percentage distribution of documents across institutions and percentile rank categories, focusing on the top ten institutions by publication volume in carbon emissions research. The Chinese Academy of Sciences stands out as the top 1% in citations for documents on carbon emissions in the construction industry. In surveys and studies conducted,

Table 1. Basic bibliometric indicators of articles on carbon emissions in construction

Quantity	Bibliometric index
833	Total number of published documents
27,551	Total number of citations
33.07	Average number of citations
15	Median number of citations
791	Number of documents in Q1 journals
94.95 %	Percentage of documents in Q1 publications
72	Number of highly cited documents in the top 1% category
9.10 %	The percentage of documents in the top 1% by citations

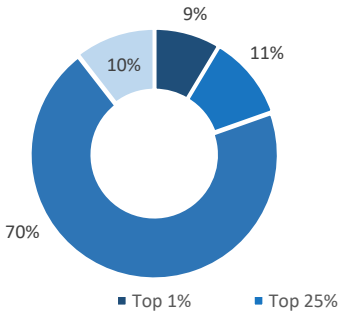

Figure 9. Document distribution based on citation categories in carbon emissions in construction

Wang Qiang has received the highest number of citations in the field of carbon emissions research. A summary of the results of the bibliometric analysis is presented in Figure S6.

Discussion

This research analyzed all documents on carbon emissions in the construction industry published by Elsevier and indexed by the WoS Core Collection from 2015 to 2024. Given the growing importance of reducing carbon emissions, particularly in the construction industry, the study's findings are highly relevant. The research explored various aspects, including document type, publication year, subject classification, publication names, co-authorships, citation impacts, and subject classifications using bibliographic coupling networks and word co-occurrence networks. This comprehensive approach, especially regarding joint research on construction and carbon emissions, provides valuable insights.

The field of carbon emissions and construction has seen a significant rise in published articles, peaking in 2023 (17) (Figure 3). Historically, until 2015, dominant subject areas included environmental science, ecology, engineering, and public health (20). Since then, the focus has shifted toward green and sustainable technologies and environmental engineering, driven by the growing emphasis on sustainability. Despite these advancements, deficiencies and gaps remain in energy, fuel, and computer science applications that require further research. Key journals for publishing research in this field include the *Journal of Cleaner Production*, *Sustainable Cities and Society*, and *Science of the Total Environment* (Figure 3). These journals publish a high volume of papers in this field because they focus on sustainability, environmental impact, and innovative solutions to reduce carbon emissions. Their interdisciplinary nature attracts researchers from engineering, environmental science, and urban planning, making them key platforms for disseminating advancements in sustainable construction and green technologies. Researchers are encouraged to consult these journals and consider publishing their work in them.

Regarding institutional contributions, Chinese universities, notably the Chinese Academy of Sciences, lead research on carbon emissions and related construction (Figure S3). While countries such as the United States and the United Kingdom have historically made significant contributions (17,40), Chinese researchers have emerged as frontrunners in recent years (Figure 4). China leads in this research due to rapid urbanization, strong sustainability policies, and significant academic funding, with most collaborations occurring domestically. Regarding top authors, who have received less attention in previous research, Chinese authors dominate in terms of the number of published articles. This dominance is due to substantial research funding, sustainability policies, and high academic output. Cai Weiguang, Chen Bin, and Zhang Xiocun lead in publications related to the construction industry and carbon emissions (Figures 5 and 6). These observations underscore China's pivotal role in advancing research on carbon emissions and its potential to drive innovation and future collaborative research initiatives with its universities.

In the thematic analysis of documents (Figure 7), researchers identified 16 broad topics, with urbanization and carbon emissions being prominent, reflecting increased research interest following the Paris Agreement. In contrast, energy-related topics, including optimization and regenerative energy systems, are less represented, highlighting a notable gap. The gap in energy-related topics may stem from their complex, interdisciplinary nature. Optimizing energy consumption and adopting renewable energy, especially in construction, could significantly reduce carbon emissions. Additionally, although crucial, the calculation and analysis of life-cycle carbon emissions rank lower in bibliographic and word co-occurrence analyses. Life-cycle analysis ranks lower due to its complexity and the difficulty of obtaining and integrating detailed data into broader carbon emissions studies. Enhancing research in this area, particularly in material life-cycle assessments, could lead to significant advancements.

Analysis of article vocabulary on carbon emissions

and greenhouse gases reveals six main categories (Figure 8). In the 1990s, the focus was predominantly on "climate change," reflecting early research interests. As understanding of greenhouse gases grew, the term "greenhouse gases" became more prevalent. Post-2015, following the Paris Agreement, there has been increased focus on "greenhouse gas emissions," indicating heightened research interest. Recently, "energy" has gained prominence due to its role in global greenhouse gas emissions. These shifts in terminology reflect evolving research priorities and are expected to continue as global challenges change.

Most highly cited documents on carbon emissions and construction are published in Q1 journals, with fewer than 10% of articles in each category achieving top-1% citation status, highlighting the importance of Q1 journals for maximizing citations (Table 1, Figure 9). The top 1% of citations are dominated by subject categories including "Engineering, Environmental; Environmental Sciences" and "Construction & Building Technology; Green & Sustainable Science & Technology; Energy & Fuels." Q1 journals dominate citations due to their rigorous peer review, broad visibility, and influence in high-impact fields such as environmental engineering and sustainability. Researchers are advised to focus on these topics to improve visibility and citation rates. The Chinese Academy of Sciences leads in citation counts (Figure S5), and Wang Giang is the most cited author in carbon emissions research. Collaborating with Chinese authors and institutions can boost researchers' citation rates worldwide.

The study utilized the WoS Core Collection for its comprehensive coverage of peer-reviewed research; however, this introduced limitations, including language bias toward English publications and an emphasis on high-impact journals, which may underrepresent work from developing countries. Additional constraints include a limited keyword scope, potentially excluding interdisciplinary subjects not explicitly labelled, and reliance on indexed documents that may overestimate relevance and delay citations for newer publications. These factors suggest the need for cautious interpretation of the findings. These limitations should be considered, and future research should incorporate a broader range of data sources and qualitative methods to provide a fuller understanding of the field.

Future research should adopt interdisciplinary approaches to better address gaps in energy management, life-cycle analysis, and carbon capture technologies. Emphasis should be placed on examining the link between fossil fuel use and industry-specific emissions, especially in the construction sector. Broader inclusion of social and economic impacts, along with the integration of qualitative methods and diverse data sources, is essential for advancing sustainable development strategies.

Conclusion

In the realm of carbon emissions research, several critical deficiencies and challenges warrant attention, including inadequate research on energy management, which is crucial for optimizing resource use and reducing emissions in line with sustainable development goals. Life-cycle assessment is essential for understanding the long-term environmental impacts of construction materials and processes and for supporting sustainable decision-making. Carbon capture and storage technologies are vital for mitigating greenhouse gas emissions, contributing directly to climate change mitigation targets. Additionally, understanding the social and economic impacts of carbon-reduction policies is necessary to ensure equitable and effective transitions towards a more sustainable, low-carbon economy.

Furthermore, there is a pressing need for more extensive exploration of innovative technologies and strategies to further reduce carbon emissions, particularly in the construction industry. Efforts should focus on developing methods to accurately calculate and reduce the carbon footprint of construction materials and processes, enhance operational efficiency, and promote sustainable construction practices across the industry. Addressing debates over the precise estimation of carbon emission life cycles is also crucial, as this area offers significant potential for improving predictions of actual emissions. Moreover, integrating computer and IT tools, including building information modelling and machine learning, will be pivotal. These technologies can support global researchers in more effectively estimating and achieving reductions in carbon emissions. Continued research and innovation in these fields are essential to advancing solutions that effectively mitigate carbon emissions, combat climate change, and foster a sustainable and environmentally friendly construction industry.

This review has several limitations that readers should consider. Firstly, this paper relies solely on literature data sourced from the WoS Core Collection database, which may not encompass all literature within the domain. While the WoS database is widely used, its comprehensiveness cannot be guaranteed. Furthermore, the majority of the extracted data come from journal articles, potentially excluding other forms of literature on carbon emissions. Additionally, the filtering process based on title and author keywords in the WoS Core Collection may have missed studies that do not explicitly mention carbon emissions in their titles. Nevertheless, this scientometric analysis offers a comprehensive overview of global research on carbon emissions, providing valuable insights into key authors, institutions, countries, and publication trends in this field, aiding researchers, government bodies, and practitioners in gaining a deeper understanding. The findings from this study can serve as a foundation for informing policy development and supporting carbon emission control,

as well as for improving indicators of environmental sustainability, especially in the construction sector.

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Competing interests
The authors declare that there is no conflict of interest.

Ethical issues
This study is part of a doctoral thesis in architecture, titled "The principles of optimal facade design of Kish high-rise buildings based on the maximum reduction of carbon emissions." In addition, data will be made available on request.

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Supplementary file
Supplementary File 1 contains Figures S1-S6.

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