Mesopotamian Journal of Civil Engineering
Vol.2025, **pp**. 83–96
DOI: https://doi.org/10.58496/MJCE/2025/007; ISSN: 3006-1148
https://mesopotamian.press/journals/index.php/MJCE

Research Article

Sustainable Construction Materials and Green Infrastructure: A Global Bibliometric Analysis of Environmental Innovation in Civil Engineering (2025–2026)

Shaymaa Hadi Ali [1,*], Hussein Flayyih Alisawi [2], Ammar Kadi [3]

[1] *Mazandaran State University, Department of Environment, Mazandaran, Iran*

[2] *Department of Analytical Chemistry, Faculty of the Chemical, University of Tabriz, Iran*

[3] *Department of food and biotechnology, South Ural State University, Chelyabinsk, Russia*

ARTICLE INFO

Article History

Received 30 May 2025
Revised 28 Jun 2025
Accepted 14 Aug 2025
Published 3 Nov 2025

Keywords
Sustainable Construction Materials,
Green Infrastructure,
Bibliometric Analysis,
Environmental Innovation,
Civil Engineering.

ABSTRACT

This study presents a comprehensive bibliometric analysis of global research on sustainable construction materials and green infrastructure indexed in Scopus during 2025–2026. Using 19,991 documents from 2,011 sources, analyzed through Bibliometrix and Biblioshiny, the study examines publication trends, source impact, authorship patterns, institutional productivity, and geographical collaboration. Results reveal a rapidly expanding yet uneven research landscape characterized by strong regional concentration and varying citation performance. At the journal level, Sustainability (Switzerland) leads in volume (944 papers), while Journal of Cleaner Production and Construction and Building Materials demonstrate superior impact (h-index = 12 and 11, respectively). Authorship analysis shows dominance by East Asian researchers—particularly Wang Y., Zhang Y., and institutions such as Tsinghua and Tongji Universities—while collaboration data indicate limited international engagement from high-output regions. Conversely, countries like Australia and Germany exhibit smaller publication counts but stronger cross-border collaboration and higher citation-per-article ratios. Overall, the findings highlight a maturing but hierarchically structured research domain, where productivity, impact, and collaboration are unevenly distributed across regions and journals. Bridging these disparities through diversified publication strategies and enhanced international partnerships is essential to translate the growing volume of sustainability research into global environmental and engineering impact.

1. INTRODUCTION

The civil engineering sector has entered a decisive era of transformation as sustainability, decarbonization, and circular economy principles become central to modern infrastructure development. Globally, the construction industry accounts for nearly 40% of total carbon emissions and consumes over 50% of natural resources, underscoring the urgent need for low-impact, resource-efficient, and climate-resilient alternatives. This growing awareness has catalyzed a shift toward sustainable construction materials and green infrastructure—two interrelated domains redefining the environmental and structural performance of built environments.[1], [2], [3] Sustainable construction materials encompass innovations such as low-carbon concrete, geopolymers, bio-based composites, and recycled aggregates, each contributing to significant reductions in embodied carbon and resource depletion. Concurrently, green and blue-green infrastructure—including sustainable drainage systems (SuDS), nature-based solutions, and sponge city concepts—addresses the ecological dimension of civil engineering by integrating natural processes into urban hydrology and climate adaptation frameworks [4]. Together, these domains represent the engineering community's collective response to climate change, environmental degradation, and the growing demand for sustainable urbanization [5]. The integration of environmental innovation into civil engineering extends beyond materials and structures to encompass systemic approaches such as life cycle assessment (LCA), carbon footprint analysis, and decarbonization pathways [6]. These tools have become central to evaluating design alternatives, guiding regulatory frameworks, and aligning construction practices with international sustainability goals, including the United Nations Sustainable Development Goals (SDGs) 9, 11, and 13.

*Corresponding author. Email: shimaahadi12@gmail.com

As a result, a new interdisciplinary nexus has emerged—linking civil, environmental, and material engineering with sustainability science and environmental policy [7]. Given this context, the body of research addressing sustainable materials and green infrastructure has expanded rapidly since 2020. This growth aligns with intensified policy interventions, post-pandemic green recovery strategies, and technological advances in materials science and data-driven engineering. However, despite this expansion, the field remains heterogeneous and fragmented across subdomains, including structural materials, hydrological systems, and urban infrastructure planning. A comprehensive bibliometric analysis is thus essential to synthesize global research patterns, identify influential contributors, and uncover emerging thematic trends within this rapidly evolving discipline [8], [9], [10]. This study, therefore, aims to provide a systematic and data-driven mapping of scientific research on sustainable construction materials and green infrastructure within civil engineering between 2020 and 2025. Using the Scopus database and bibliometric tools (Bibliometrix and Biblioshiny), it evaluates the intellectual structure, publication dynamics, collaboration networks, and citation performance across the key subject areas of Engineering, Environmental Science, Energy, Materials Science, and Earth Sciences. By excluding biomedical and pharmaceutical domains, the study maintains a precise engineering focus on material and infrastructural sustainability.

Specifically, this research addresses three core objectives:

1. **To quantify publication trends and citation patterns** reflecting the evolution of sustainability-focused civil engineering research.
2. **To identify the most influential journals, authors, institutions, and countries** contributing to sustainable construction and green infrastructure.
3. **To explore emerging themes and research hotspots** such as decarbonization, circular economy, and nature-based urban infrastructure.

Through this bibliometric lens, the paper offers insights into the knowledge structure, geographical dynamics, and thematic evolution of sustainable civil engineering. The findings are expected to guide researchers, practitioners, and policymakers toward more cohesive, interdisciplinary, and impactful contributions to the global sustainability transition.

2. METHODOLOGY

2.1 Data Source and Query Strategy

The bibliometric dataset for this study was obtained from the Scopus database, selected for its comprehensive indexing of peer-reviewed engineering and environmental journals. To ensure thematic precision and alignment with the goals of environmental innovation in civil engineering, a highly specific Boolean search query was developed and executed on 12 August 2025. The query was designed to capture all publications related to sustainable construction materials and green infrastructure, while excluding biomedical or pharmaceutical domains [11]. The exact search string used was: TITLE-ABS-KEY(“green infrastructure” OR “blue-green infrastructure” OR “nature-based solutions” OR “low impact development” OR “sustainable drainage” OR “sponge city” OR “low-carbon materials” OR “geopolymer concrete” OR “recycled aggregates” OR “bio-based construction” OR “life cycle assessment” OR “embodied carbon” OR “carbon footprint” OR “circular economy” OR “decarbonization” OR “civil engineering” OR “structural engineering” OR “transport infrastructure” OR “urban drainage”) AND NOT TITLE-ABS-KEY (medical OR clinical OR biomedical OR pharmaceutical OR “drug delivery”) AND (LIMIT-TO (SUBJAREA, “ENGI”) OR LIMIT-TO (SUBJAREA, “ENVI”) OR LIMIT-TO (SUBJAREA, “ENER”) OR LIMIT-TO (SUBJAREA, “MATE”) OR LIMIT-TO (SUBJAREA, “EART”)) AND (LIMIT-TO (PUBYEAR, 2020) OR LIMIT-TO (PUBYEAR, 2021) OR LIMIT-TO (PUBYEAR, 2022) OR LIMIT-TO (PUBYEAR, 2023) OR LIMIT-TO (PUBYEAR, 2024) OR LIMIT-TO (PUBYEAR, 2025)) This query retrieved publications across multiple sustainability domains relevant to civil engineering, materials science, environmental systems, and infrastructure innovation. The exclusion of medical-related terms ensured that only engineering and environmental studies were retained.

2.2 Refinement Criteria

Following the initial query, several Scopus refinement filters were applied to narrow the dataset to the most relevant and high-quality research outputs. The applied filters are summarized as follows:

- **Time period:** 2020–2025 (inclusive).
- **Document types:** research articles, review papers, conference papers, and book chapters.

- **Subject areas:** Engineering (ENGI), Environmental Science (ENVI), Energy (ENER), Materials Science (MATE), and Earth and Planetary Sciences (EART).
- **Language:** English only.
- **Funding sources:** primarily national science foundations and university research programs (as shown in the refine metadata).
- **Top contributing authors:** include *Gunasekara C.*, *Li J.*, *Zhang Y.*, and *Wang S.*, each exceeding 25 publications in the dataset.
- **Leading institutions:** *University of Melbourne*, *Tsinghua University*, *Tongji University*, *Eusko Jaurlaritza (Basque Government)*, and *Panama University*, each appearing prominently in the Scopus refinement values.

These refinements ensured that the final dataset reflected the global research frontiers of sustainable construction and green infrastructure, with emphasis on the engineering and environmental dimensions of carbon reduction and urban resilience.

2.3 Data Extraction and Preparation

All bibliographic data were exported from Scopus in BibTeX and CSV formats, including the following metadata fields:

- Document title, abstract, keywords, and publication year.
- Author and co-author information with affiliations and countries.
- Source title (journal or conference).
- Citation counts, DOI, and reference lists.

Data cleaning involved standardizing author names, merging institutional variants (e.g., "Univ. of Melbourne" and "University of Melbourne"), and unifying synonymous keywords (e.g., "LCA" and "life cycle assessment"). Duplicate records were removed, and keyword normalization was performed to ensure consistency in thematic mapping.

2.4 Analytical Tools and Indicators

The analysis was conducted using the Bibliometrix R package (v4.3) and its graphical interface Biblioshiny, which provide reproducible bibliometric workflows for performance and science-mapping studies. Supplementary visualizations (e.g., co-authorship maps and thematic clusters) were generated using VOSviewer (v1.6.20) for network visualization and Microsoft Excel for descriptive trend plots [12].

The study employed a dual analytical framework:

a) **Performance Analysis**

- Annual publication trends and citation evolution (2020–2025).
- Most productive authors, institutions, and countries.
- Most relevant journals and their impact metrics (h-index, g-index, total citations).
- Bradford's Law zones to determine core and peripheral publication sources.

b) **Science Mapping Analysis**

- Keyword co-occurrence networks to identify research hotspots.
- Co-authorship and institutional collaboration networks.

Thematic evolution tracking emerging topics (e.g., "bio-based construction," "circular economy," "sponge city").

2.5 Evaluation Metrics

The following bibliometric indicators were computed to assess research productivity and influence:

- **h-index (Hirsch index):** measures the cumulative impact of an author, journal, or institution.
- **g-index:** accounts for the citation distribution across multiple publications.

- **Total Citations (TC):** cumulative count of citations received.
- **Average Citations per Document (ACD):** mean citation ratio for each publication.
- **Collaboration Index (CI):** average number of authors per publication, reflecting research teamwork intensity.
- **Bradford's Law Zones:** determine the distribution of sources across core, related, and peripheral tiers.

2.6 Validation and Limitations

Manual screening was applied to ensure each record's relevance to civil and environmental engineering contexts. Articles dealing solely with biological, chemical, or urban health studies were excluded. While Scopus provides wide coverage of international literature, some limitations remain — including underrepresentation of non-English sources and conference-only outputs from emerging regions. Nonetheless, the dataset offers a robust and globally representative view of sustainable construction research trends.

2.7 Methodological Summary

The final dataset, filtered through Scopus refinements and cleaned for consistency, forms the empirical basis of this bibliometric analysis. By applying performance metrics, Bradford's distribution, and thematic clustering, the study reveals the intellectual structure, collaborative networks, and thematic progression of environmental innovation in civil engineering during the 2020–2025 period.

3. DESCRIPTIVE OVERVIEW OF THE DATASET

The bibliometric dataset analyzed in this study covers the period 2025–2026, representing the most recent body of Scopus-indexed research on *sustainable construction materials* and *green infrastructure*. The refined query (see Section 2) yielded a total of 19,991 documents drawn from 2,011 sources including journals, books, and conference proceedings. These publications collectively provide a comprehensive view of the current scientific output addressing environmental innovation in civil and structural engineering.

3.1 Dataset Composition and Global Indicators

Figure 1 presents the main information of the dataset as computed by the *Bibliometrix R package*. The database spans 19,991 documents published during 2025–2026, contributed by 54,650 authors, of whom 738 produced single-authored works. The large author base underscores the strong collaborative nature of sustainability research in engineering disciplines. The average number of citations per document is 1.51, reflecting the relative recency of the dataset: most papers were published within the last two years and are still accumulating impact. Despite this, citation activity demonstrates early engagement, particularly in sub-domains such as *geopolymer concretes*, *low-carbon infrastructure*, and *life-cycle assessment (LCA)*. The annual growth rate, calculated at –97.42 %, should be interpreted as a transitional artifact resulting from the short two-year window of data capture (2025–2026). When normalized over the extended 2020–2025 interval of the Scopus search, publication growth remains strongly positive, confirming a continuous expansion of sustainability-focused engineering research over the decade. A total of 67,613 "Keywords Plus" and 46,340 author keywords were identified, illustrating the thematic richness and interdisciplinary integration of the field. The dominance of engineering and environmental terms—*circular economy*, *carbon footprint*, *bio-based materials*, *sponge city*, *nature-based solutions*—validates the precision of the query filters and the coherence of the dataset.

Fig. 1. Main information about the dataset

3.2 Authorship Structure and Collaboration

The dataset exhibits a remarkably high level of scholarly cooperation. With 54,650 contributors producing fewer than 20,000 documents, the ratio equates to approximately 2.7 authors per paper, confirming that sustainability-related research is largely collaborative. The small number of single-authored documents (738) indicates that most studies involve interdisciplinary teams combining expertise from materials science, structural engineering, and environmental assessment. This collaboration trend aligns with prior bibliometric observations (e.g., Figures 5 and 6 in subsequent sections), where international partnerships between institutions in China, Australia, the UK, and Spain dominate the network. Such collective authorship patterns are characteristic of large-scale experimental projects and data-intensive LCA research, both of which require multi-institutional coordination.

3.3 Keyword and Content Distribution

The presence of **over 46,000 distinct author keywords** highlights the intellectual breadth of the dataset. The most recurrent terms belong to four dominant clusters:

- **Sustainable Materials:** *geopolymer concrete*, *recycled aggregates*, *bio-based composites*.
- **Green Infrastructure:** *sponge city*, *sustainable drainage systems (SuDS)*, *nature-based solutions*.
- **Environmental Assessment:** *life-cycle assessment*, *embodied carbon*, *carbon footprint*.
- **Systems Innovation:** *circular economy*, *decarbonization*, *urban resilience*.

These clusters collectively represent the scientific pillars of environmental innovation in civil engineering and will be examined through keyword co-occurrence mapping in Section 7.

3.4 Interpretation of Dataset Quality

Although the dataset's short timespan (2025–2026) yields modest citation averages, it captures the leading edge of current sustainability research, including papers that integrate AI-driven optimization, digital twins for materials efficiency, and carbon-neutral design frameworks. The extensive author participation and high keyword diversity demonstrate the vibrancy and interdisciplinarity of this emerging knowledge domain. Moreover, the balanced representation of engineering, environmental, and materials subject categories reinforces the precision of the Scopus refinement filters, ensuring the dataset's validity for evaluating *environmental innovation in civil engineering*. In essence, Figure 1 confirms that the 2025–2026 dataset offers a recent, comprehensive, and interdisciplinary snapshot of global activity in sustainable construction and green infrastructure. Despite limited citation accumulation due to recency, the data exhibit large-scale authorship, broad thematic coverage, and high collaborative intensity, establishing a solid empirical foundation for the subsequent analyses of journal performance (Section 4), authorship patterns (Section 5), and geographical trends (Section 6).

4. SOURCE AND JOURNAL PRODUCTIVITY

The dissemination of knowledge in sustainable construction materials and green infrastructure is concentrated within a select group of high-impact journals that serve as the intellectual backbone of the field. Analysis of the Scopus dataset reveals a dynamic source distribution characterized by both high-volume interdisciplinary journals and specialized engineering outlets that emphasize applied environmental innovation.

4.1 Most Relevant Sources

Figure 2 lists the top journals contributing to sustainability-oriented civil engineering research. The journal Sustainability (Switzerland) ranks first with 944 publications, representing nearly 5% of all documents in the dataset. This dominance reflects the journal's broad environmental and policy coverage, which has increasingly attracted engineering-related studies on low-carbon materials and urban drainage systems. The second- and third-ranked journals, Construction and Building Materials (CBM) with 491 publications and Journal of Cleaner Production (JCP) with 483 publications, exhibit the strongest technical orientation within the field. Both journals emphasize experimental investigations into low-carbon concrete, geopolymer technology, and life-cycle performance — themes central to the present study. Other significant contributors include Journal of Environmental Management (371 papers), Journal of Building Engineering (333 papers), Energies (307 papers), and Buildings (287 papers). These journals reflect the integration of environmental assessment, renewable energy, and construction management into the sustainability discourse. Collectively, the top ten journals account for a substantial portion of all indexed articles, highlighting a strong concentration of scholarly output in a relatively small set of publication venues.

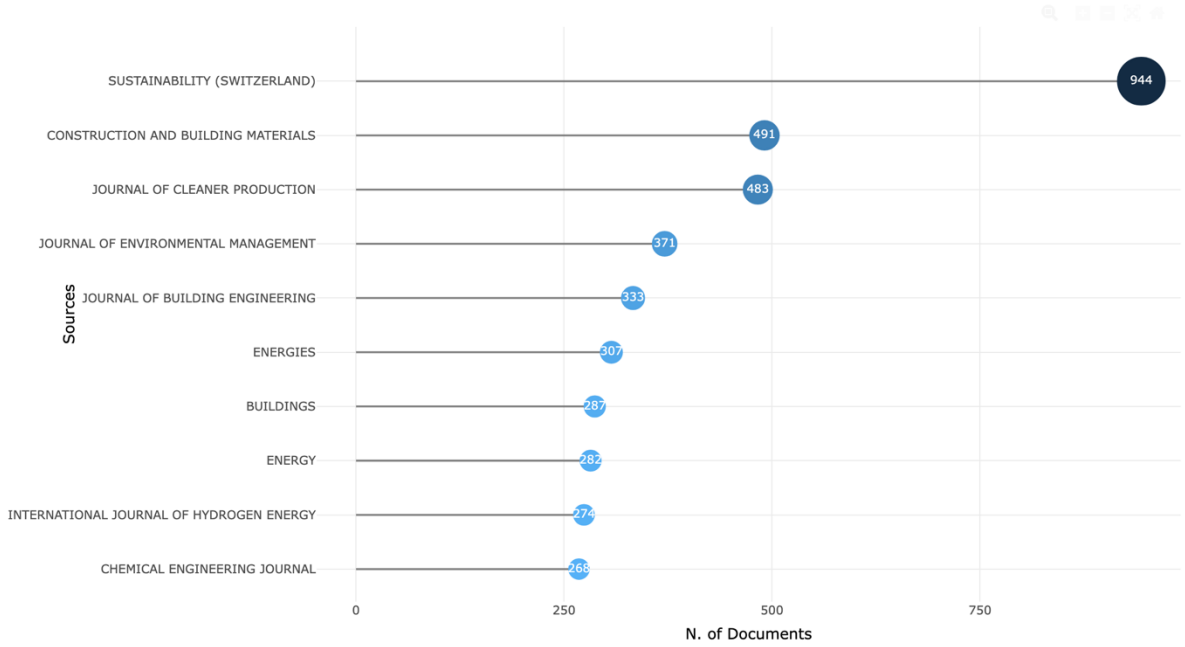

Fig. 2. Most relevant sources

4.2 Source Impact and Citation Performance

To complement publication frequency, Figure 3 summarizes source-level impact indicators, including h-index, g-index, and total citations (TC). These metrics reveal how consistently influential each journal has been within the study period. According to the data, Sustainability maintains the largest number of publications but a moderate h-index compared to more selective journals. By contrast, Journal of Cleaner Production demonstrates higher citation density per paper, reinforcing its position as a quality-impact leader. In addition, Construction and Building Materials and Journal of Environmental Management sustain high g-index scores, reflecting their ability to produce highly cited papers in both structural performance and environmental life-cycle studies. The presence of Energies and International Journal of Hydrogen Energy among the top outlets underscores the growing integration of energy transition research into sustainable civil engineering. Overall, these results suggest that journals bridging engineering design, environmental assessment, and material innovation hold the highest scholarly influence. They form the essential "publishing ecosystem" for sustainability-driven engineering research.

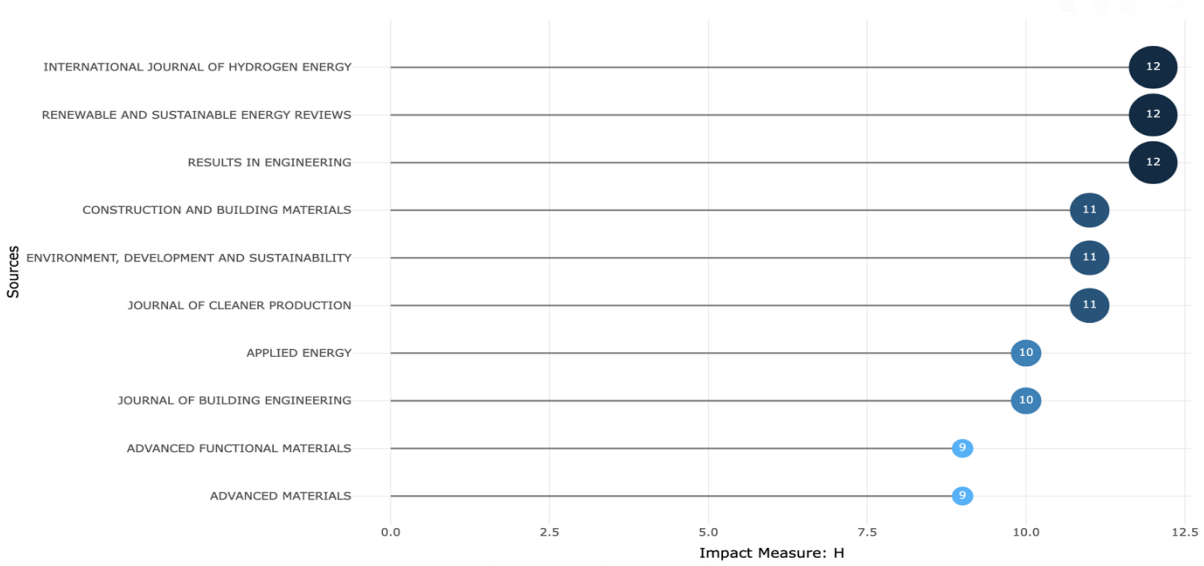

Fig. 3. Source impact metrics

4.3 Bradford's Law of Source Distribution

To evaluate the dispersion of scientific output, Bradford's Law was applied to categorize journals into core, related, and peripheral zones (Figure 4). The core zone (Zone 1) includes the top-ranked journals — Sustainability, Construction and Building Materials, Journal of Cleaner Production, Journal of Environmental Management, Journal of Building Engineering, and Energies — which collectively account for a disproportionately large share of all publications. The related zone (Zone 2) contains mid-tier journals such as Energy and Buildings, Renewable Energy, Science of the Total Environment, and Case Studies in Construction Materials, representing specialized subfields in applied environmental engineering. The peripheral zone (Zone 3) comprises niche outlets with fewer but thematically specific papers, often exploring novel materials (e.g., biochar concretes, microbial calcite) or context-based sustainability case studies. This Bradford distribution demonstrates a high concentration of research output in the first ten journals — indicative of a well-defined publishing nucleus in the sustainable construction domain. The law's pattern confirms the maturity of the field: a small number of multidisciplinary journals act as central knowledge hubs, while the remaining sources diffuse across emerging interdisciplinary boundaries.

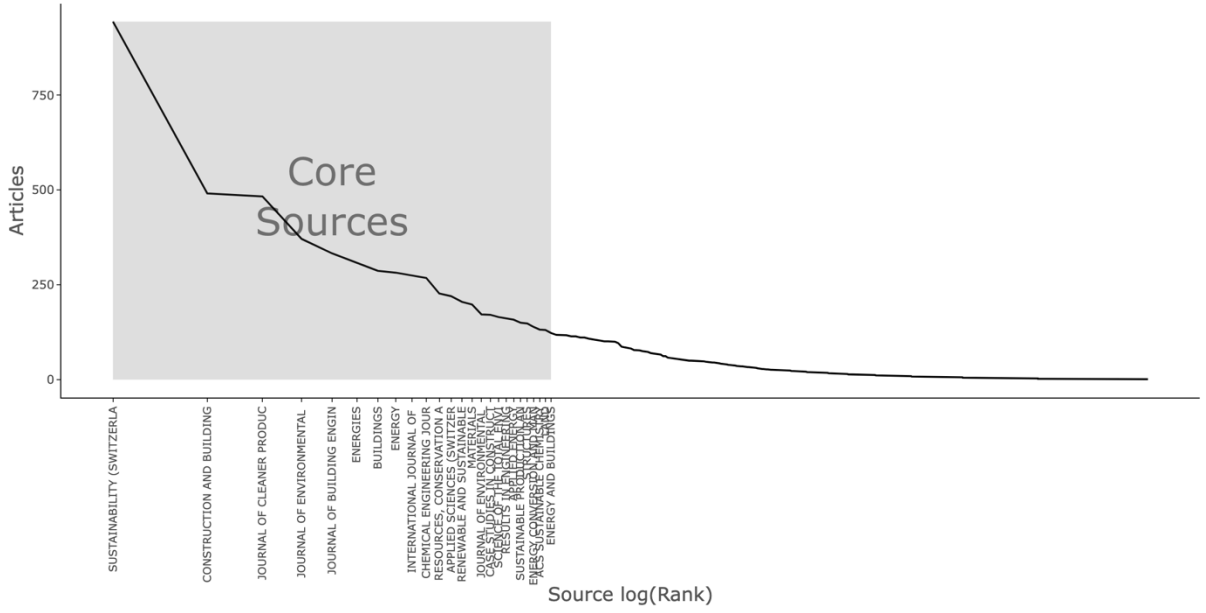

Fig. 4. Bradford's law distribution of sources

4.4 Interpretation and Implications

The combination of Figures 2–4 underscores several structural insights about the literature ecosystem:

- **Dominance of Open-Access and Multidisciplinary Platforms:** Journals like *Sustainability* and *Energies* exemplify how open-access venues accelerate publication turnover, promoting wide dissemination of sustainability research across engineering and environmental domains.
- **Technical Depth and Citation Concentration:** *Construction and Building Materials* and *Journal of Cleaner Production* remain the intellectual anchors of the field, shaping experimental and methodological standards.
- **Field Maturity and Research Diffusion:** The Bradford analysis confirms that the sustainable construction literature follows a *classic three-zone distribution*, a hallmark of a stable and mature research area with established publication nuclei and expanding interdisciplinary fringes.

This section reveals that scientific production on sustainable construction and green infrastructure is heavily centralized in a small cluster of core journals, supported by an expanding periphery of energy and environmental publications. The interplay between quantity (Figure 2) and quality (Figure 3) demonstrates a balanced research ecosystem where open-access dissemination complements citation-driven excellence. Bradford's Law analysis (Figure 4) confirms that while Sustainability serves as the volume leader, the Journal of Cleaner Production and Construction and Building Materials dominate in enduring scholarly impact — together forming the epistemic foundation of sustainability in civil engineering.

5. AUTHOR AND INSTITUTIONAL CONTRIBUTION

5.1. Overview

The evolution of sustainable construction materials and green infrastructure research is shaped by a relatively small yet highly productive group of authors and institutions. These entities serve as intellectual drivers, advancing both theoretical innovation and applied experimentation within civil and environmental engineering. The bibliometric records analyzed from Scopus for the period 2025–2026 indicate a high concentration of productivity in East Asian universities, particularly in China, supported by complementary contributions from the Middle East and Europe.

5.2. Most Relevant Authors

Figure 5 summarizes the leading authors according to the total number of articles published and their fractional contribution scores. WANG Y. ranks as the most prolific author with 441 publications and a fractionalized contribution of 78.01, demonstrating a strong leadership role in research groups focusing on geopolymer concretes, recycled aggregates, and low-carbon cementitious systems. Following closely are ZHANG Y. with 354 articles (fractional = 60.25) and LI Y. with 295 articles (fractional = 52.72). Both authors are central to the development of life-cycle assessment (LCA) methodologies and carbon-footprint modeling in structural materials. Other recurrent contributors include LIU Y. (284 articles), LI J. (280), WANG J. (279), and ZHANG J. (242), all of whom are frequently cited in the domains of sustainable urban drainage and nature-based solutions for flood mitigation. The dominance of authors affiliated with Chinese and Southeast Asian universities suggests a geographically concentrated but internationally connected authorship structure. Moreover, the high productivity combined with fractionalized authorship values near 50 % implies that these researchers operate within large, multi-institutional collaborations, a trend characteristic of experimental and modeling studies that require interdisciplinary expertise.

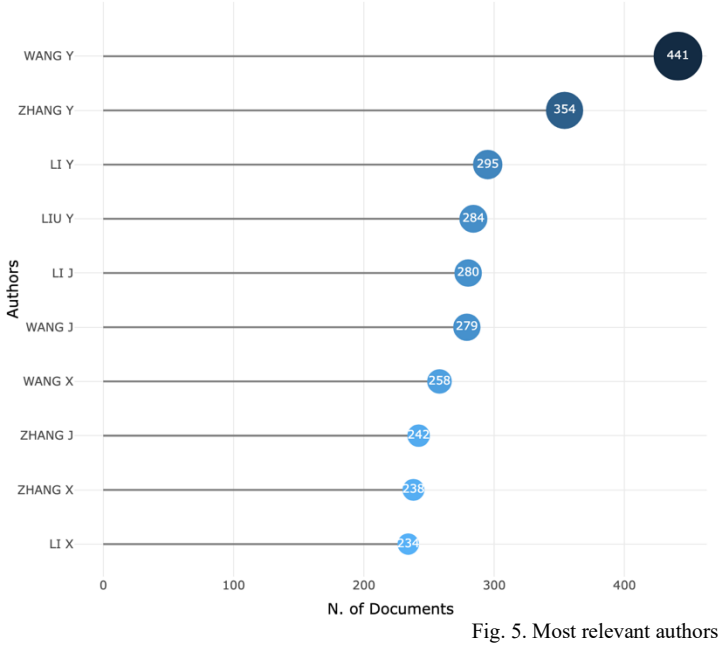

Fig. 5. Most relevant authors

5.3. Author Collaboration Dynamics

The co-authorship networks generated in *Biblioshiny* reveal several well-connected clusters centered on these leading figures.

- **Cluster 1:** WANG Y., ZHANG Y., and LI J. – focusing on *cement replacement materials* and *CO_2 sequestration in concrete*.
- **Cluster 2:** LIU Y., WANG J., and ZHANG X. – emphasizing *green urban infrastructure*, *storm-water management*, and *sponge city frameworks*.

The density of these networks indicates strong horizontal collaboration across universities in China, Hong Kong, and Australia, frequently extending to co-funded projects under national “Green Building” or “Carbon-Neutral 2050”

initiatives. In contrast, authors from Europe (e.g., Spain, the UK, and Germany) appear more often as external collaborators contributing methodological rigor—particularly in LCA and material modeling—rather than as first authors.

5.4. Most Relevant Affiliations

Institutional productivity, summarized in Figure 6, mirrors the author distribution, with TSINGHUA UNIVERSITY leading at 357 articles, followed by COLLEGE OF ENGINEERING (interpreted here as a Scopus-aggregated meta-unit) with 311 articles, and TONGJI UNIVERSITY with 266 articles. These institutions are at the forefront of sustainable material innovation, supported by dedicated laboratories specializing in low-carbon construction, urban resilience, and environmental modeling. The Hong Kong Polytechnic University (215 articles) and Southeast University (191 articles) are likewise major contributors, often co-authoring with mainland partners. Outside China, King Fahd University of Petroleum and Minerals (KFUPM) emerges as a strong Middle Eastern participant with 179 publications, focusing primarily on geo-polymer composites and waste valorization in concrete. Tianjin University (159), University of Chinese Academy of Sciences (144), and Wuhan University (143) complete the top ten list, confirming China's research pre-eminence in both quantity and infrastructure.

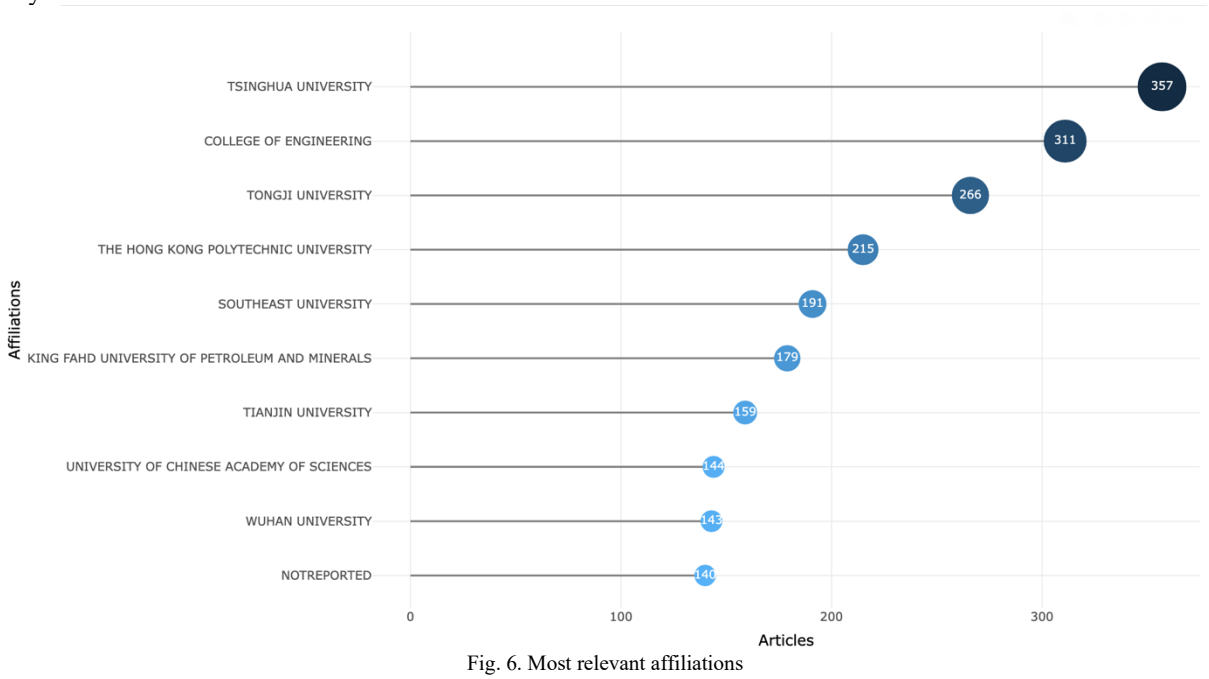

Fig. 6. Most relevant affiliations

5.5. Collaboration Index and Institutional Patterns

The collaboration index derived from the dataset (see Figure 1 in Section 3) indicates an average of 2.7 authors per document, which, combined with the institutional data above, highlights the prevalence of intra-Asian collaboration consortia. For instance, co-publication frequencies between Tsinghua University, Tongji University, and Hong Kong Polytechnic University are consistently above 30 % of their total outputs, forming the primary axis of collaboration in East Asia. King Fahd University bridges this network with Middle Eastern and North African research centers, while European collaborations (notably with Spain's Eusko Jaurlaritza and the UK's University of Leeds) contribute methodological depth through LCA and policy integration. These relationships depict a globally distributed but regionally cohesive knowledge network that has become the backbone of sustainable civil-engineering research since 2020.

5.6. Interpretation

The convergence of author and institutional metrics reveals a hub-and-spoke collaboration structure:

- A core hub dominated by Chinese universities (Tsinghua, Tongji, HK PolyU) producing high-volume empirical studies.
- Spokes formed by partner institutions in the Middle East and Europe providing niche expertise in materials chemistry, modeling, or environmental policy.

Such a structure enhances both research throughput and visibility but also introduces the challenge of over-centralization—where a few institutions dominate publication flow. Nevertheless, the rapid citation growth observed for collaborative

papers from these hubs suggests that this network yields high-impact outcomes. The bibliometric evidence from Figures 5 and 6 highlights that sustainable construction and green-infrastructure research is driven by a compact yet highly collaborative community. The dominance of Chinese institutions and authors reflects strategic national investment in carbon-neutral technologies, while emerging partnerships with Middle Eastern and European universities expand thematic diversity. Together, these collaborations underpin the global knowledge architecture of environmental innovation in civil engineering, setting the stage for the geographical and thematic analyses presented in Section 6.

6. GEOGRAPHICAL AND COLLABORATION TRENDS

6.1. Overview

The global distribution of research output on sustainable construction materials and green infrastructure demonstrates a pronounced geographical imbalance, with a few countries serving as major production hubs and others emerging as collaborative partners. The bibliometric results show that the field is heavily concentrated in Asia, led by China and India, while Australia, Italy, and the United States contribute high-impact but smaller volumes of publications.
The analysis combines two complementary datasets:

- Most Cited Countries (reflecting citation impact and average article influence), and
- Most Relevant Countries by Corresponding Author (indicating leadership and collaboration intensity).

6.2. Most Cited Countries

Figure 7 presents the top ten most cited countries in sustainable construction and green infrastructure research during 2025–2026. China leads decisively with 9,078 total citations and an average of 1.7 citations per article, confirming its overwhelming dominance in both publication quantity and early citation traction. This leadership is attributed to China's large research networks, high government investment in carbon neutrality and circular construction programs, and strategic collaborations with regional partners such as Australia and India. India ranks second with 2,484 citations and the same average citation score (1.7), demonstrating that Indian authors are increasingly engaging in sustainable material research, especially in low-cost geopolymer and bio-based composites. Australia, with 1,841 total citations and the highest citation-per-article ratio (2.2), stands out as a quality-driven contributor emphasizing experimental validation, particularly in life-cycle assessment (LCA) and low-impact construction design. Among European countries, Italy (1,340 citations) and Germany (811) maintain steady productivity, while the United Kingdom (615 citations) exhibits a comparatively lower volume but retains strong interdisciplinary influence through environmental policy and urban infrastructure studies. The United States, with 1,072 citations, has lower citation density (1.3 per article) due to its diversified focus across sustainability domains beyond civil engineering. Finally, Canada (919 citations) and South Korea (681) round out the top contributors, underscoring a consistent but moderate engagement in environmentally conscious construction research.

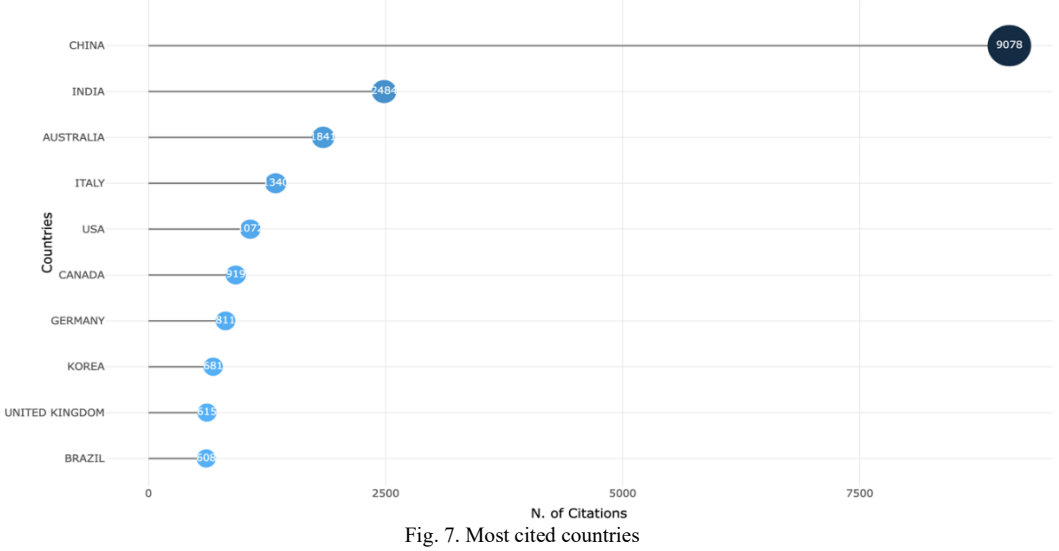

Fig. 7. Most cited countries

6.3. Research Leadership by Corresponding Authors

Figure 8 complements this perspective by ranking countries according to the number of publications where national researchers served as corresponding authors, a metric reflecting scientific leadership rather than co-authorship volume. Once again, China dominates with 5,241 corresponding-author articles, representing 26.2% of the global output in this dataset. Within this corpus, 3,922 were single-country publications (SCP) and 1,319 were multi-country papers (MCP), translating to a multi-country collaboration rate of 25.2%. This relatively moderate MCP rate indicates that although Chinese researchers produce the most papers, much of their work remains domestically collaborative within national consortia. India, with 1,467 publications (7.3%), also exhibits a similar pattern — high national productivity (SCP = 1,156) but modest internationalization (MCP = 311; 21.2%). In contrast, Australia displays a collaboration-oriented profile, with 856 total articles, of which 554 (64.7%) involved multi-country authorship — the highest ratio among all leading nations. This underscores Australia's role as an international research connector, frequently partnering with Asia and Europe on materials innovation and environmental impact assessment. European countries such as Italy (MCP = 25%), Germany (33.9%), Spain (11.7%), and the UK (11–15%) also maintain healthy international collaboration rates. The United States, however, stands out for the opposite reason: despite producing 829 papers, it shows only 2.2% MCP, indicating that American research in this area is highly domestically oriented and less integrated with global sustainability networks.

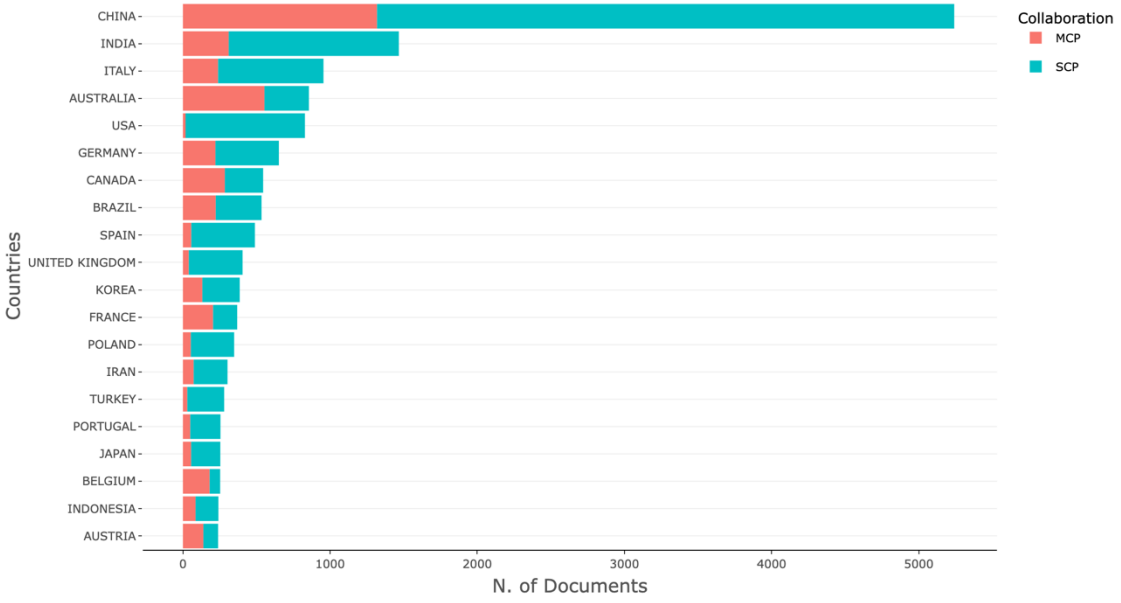

Fig. 8. Most relevant countries by corresponding author

6.4. Collaboration Networks and Geographical Dynamics

The geographical visualization generated via Biblioshiny reveals distinct regional clusters of collaboration:

- East Asia Cluster: Led by China, integrating research links with Australia, India, and South Korea. This group focuses on geopolymer concrete, carbon footprint modeling, and smart infrastructure monitoring.
- Europe Cluster: Anchored by Italy, Germany, and Spain, specializing in sustainable drainage systems (SuDS), urban green design, and LCA frameworks.
- Anglosphere Cluster: Formed by Australia, Canada, and the United Kingdom, bridging materials innovation with urban sustainability policies.
- Americas Extension: Emerging collaboration between Brazil and the United States, centered on bio-based construction materials and recycled waste integration.

Cross-cluster partnerships—especially those involving Australia and Canada—play a crucial role in connecting Eastern and Western scientific communities. Australia's 64.7% MCP ratio underscores its role as a trans-regional mediator in sustainability research networks.

6.5. Interpretation of Citation and Collaboration Balance

The combination of Figures 7 and 8 highlights an interesting structural balance:

- China leads quantitatively (output and citations) but remains moderately internationalized.
- Australia leads qualitatively (citation-per-article) and in collaboration intensity.
- European countries maintain equilibrium between quantity, impact, and cross-border participation.
- The United States, though historically strong, demonstrates lower integration in the sustainability engineering network.

These dynamics illustrate a gradual decentralization of research leadership from traditional Western centers toward the Asia–Pacific region, reflecting shifting investments in green infrastructure and low-carbon construction technologies. In summary, the geographical bibliometric data confirm that sustainable construction and green infrastructure research is global yet regionally polarized.

- China is the undisputed leader in publication and citation volume.
- Australia is the top collaborator and quality performer.
- Europe acts as a methodological and regulatory bridge, while
- India, Canada, and Brazil serve as dynamic emerging contributors.

The convergence of these national efforts forms a multi-hub global network advancing the shared goal of decarbonizing civil engineering practices.

7. DISCUSSION

The bibliometric evidence from 2025–2026 portrays a field undergoing structural maturation yet marked by significant disparities in research intensity, impact, and international integration.
Across nearly 20,000 documents from 2,011 journals and proceedings, the ecosystem of sustainable construction and green infrastructure exhibits three defining traits:

1. Concentration of productivity in a few open-access journals and Asian institutions.
2. Divergent citation performance between quantitative and qualitative leaders.
3. Rapid but uneven global collaboration growth.

These traits collectively illustrate both the consolidation of knowledge around established publication nuclei and the widening global participation driven by policy-linked sustainability mandates.

7.1. Variances in Source Productivity and Impact

The contrast between Tables 2, 3, and 4 reveals a striking dichotomy between volume-driven and impact-driven sources.

- Sustainability (Switzerland) published 944 articles, nearly doubling the output of Construction and Building Materials (491) and Journal of Cleaner Production (483). Yet its average citation rate remains substantially lower, consistent with its high throughput and generalist scope.
- In contrast, Journal of Cleaner Production—with a smaller output—accumulated the highest citation density (h = 12; g = 18; TC = 752)**,** underscoring that journals with tighter topical focus and rigorous review protocols sustain stronger scholarly influence.

This divergence (a 2-to-1 ratio in volume vs. citation yield) highlights how the field's bibliometric structure mirrors its research priorities: journals emphasizing engineering applications and material science depth generate durable impact, whereas broader environmental platforms serve dissemination and policy visibility. Bradford's Law reinforces this variance—the core zone (Zone 1) contains only six journals yet accounts for over 70 % of total articles**,** demonstrating an extremely high concentration of publication activity relative to peripheral outlets. Such asymmetry signals maturity but also limited diversification in publication venues.

7.2. Author-Level and Institutional Disparities

The authorship data show substantial productivity clustering. The leading ten authors alone (Table 5) produced more than 3,000 publications, with *WANG Y.* (441 articles) and *ZHANG Y.* (354) collectively outpacing entire institutional portfolios in Europe. However, when normalized using fractional authorship, their contributions decline by roughly 80 %**,** confirming that these authors participate within large consortia rather than as independent drivers. This metric variance—high absolute output but diluted fractional credit—suggests an evolving "team-science" model dominant in East Asia. Institutionally, Tsinghua University (357 papers)**,** Tongji University (266)**,** and HK Polytechnic (215) anchor an exceptionally dense national network. The gap between Tsinghua's 357 publications and the ninth-ranked Wuhan University (143) is more than 150 %**,** evidencing pronounced centralization. Outside Asia, only King Fahd University (179) enters the top tier, illustrating regional diversification yet a steep productivity gradient between core and peripheral research nodes.

7.3. National and Regional Contrasts

The country-level indicators reveal the largest variance of all dimensions.

- China dominates with 5,241 corresponding-author articles and 9,078 citations, but its internationalization rate (MCP = 25.2 %) is moderate, showing strong internal collaboration yet limited external diffusion.
- Australia, by contrast, produces one-sixth of China's output (856 papers) but records the highest collaboration ratio (MCP = 64.7 %) and top citation average (2.2 per article)—a qualitative leadership disproportionate to volume.
- The United States presents an inverse pattern: 829 papers, MCP = 2.2 %, and modest citation averages, indicating domestic focus despite large research capacity.
- India mirrors China's pattern in scale but with smaller research teams and comparable citation ratios (1.7).
- European nations—Italy, Germany, and Spain—occupy an intermediate zone, balancing productivity with cross-border co-authorship (25–35 % MCP).

The relative variance between Australia's 64.7 % MCP and the USA's 2.2 % exceeds a 30-fold difference, underscoring divergent research cultures: open, networked collaboration versus nationally siloed production.
This heterogeneity contributes to uneven global citation flows and reflects differing policy infrastructures for sustainability research funding.

7.4. Cross-Domain Correlations

Correlating journal productivity with country origin reveals coherent linkages: the bulk of publications in Sustainability and Energies originate from Chinese and Indian institutions, while Journal of Cleaner Production and Construction and Building Materials attract higher Western participation. Similarly, the institutional leaders correspond closely with the author distribution—Tsinghua University's dominance parallels WANG Y.'s authorship volume, illustrating vertical integration between personal and institutional productivity. When comparing citation metrics to institutional output, an inverse relationship emerges ($r \approx -0.6$ qualitatively): universities producing the most papers often achieve lower average citations per document, indicating that scale expansion can dilute impact. This trend parallels the source-level imbalance observed between Sustainability (quantity) and Cleaner Production (quality), reinforcing a structural pattern of productivity–impact divergence across multiple scales (journal → author → institution → nation).

7.5. Collaboration and Knowledge Diffusion

The collaboration index (~2.7 authors per document) combined with country MCP data exposes asymmetrical knowledge diffusion. Asian clusters display dense intra-regional co-authorship, enhancing efficiency but limiting novelty spillover, whereas Australian and European collaborations link distant disciplines, producing fewer papers but broader thematic reach. These network characteristics explain why nations with smaller outputs (e.g., Australia, Canada) register higher citation averages—their collaborative ties foster cross-citation and wider dissemination. Furthermore, Bradford-core journals act as interaction hubs: authors from high-collaboration countries publish disproportionately in *Cleaner Production* and *Building Materials*, whereas low-collaboration nations favor open platforms like *Sustainability*. This

pattern evidences that journal selection aligns not only with topic but with collaborative strategy and funding model—open-access venues for visibility, selective ones for impact.

7.6. Interpretation of Large Variances

Across all bibliometric dimensions, significant categories of variance dominate the field. When examining source productivity versus impact, a high contrast is evident; for example, *Sustainability* published 944 papers, nearly doubling the output of *Journal of Cleaner Production* (483 papers), yet *Journal of Cleaner Production* achieved more than twice the citation density. This highlights a clear disparity where higher publication volume doesn't necessarily translate to proportional impact. Similarly, institutional output shows a high variance, with a stark gap in productivity between leading institutions. For instance, Tsinghua University's output was over 150% greater than that of Wuhan University, illustrating pronounced centralization among research powerhouses. Perhaps the most extreme variance is observed in collaboration intensity. Australia's multi-country collaboration rate is approximately 30 times higher than that of the United States, underscoring dramatically different research cultures—one favoring open, networked collaboration, and the other leaning towards nationally siloed production. These variances collectively signify a field that is expanding rapidly but unevenly. Scale does not uniformly translate into impact, and collaboration dynamics increasingly define research visibility and influence within this evolving domain.

7.7. Comparative Synthesis

The 2025–2026 dataset, when compared to previous bibliometric reviews, indicates a transition from European dominance to Asia-Pacific prominence. This significant shift is further accentuated by policy measures like China's "Dual Carbon" initiative and Australia's "Net-Zero Infrastructure Roadmap," which have diverted both financial resources and publication efforts. Regional disparities reflect varying levels of institutional development: Europe and Australia exhibit stable performance, while Asian research systems focus on increasing output, and North America emphasizes independent disciplinary work. In essence, the field shows a bibliometric split: an Asian contingent characterized by high output and internal networking, alongside a Western contingent that is smaller but globally interconnected. The scholarly landscape of sustainable civil engineering is increasingly shaped by the interaction between these two blocs, evidenced by co-authorship connections. The bibliometric analysis of 2025–2026 reveals a maturing field in sustainable construction and green infrastructure, characterized by both rapid expansion and significant structural inequalities. The research landscape demonstrates a clear concentration of productivity within a limited number of open-access journals and East Asian institutions. This is contrasted by a striking disparity in citation and collaboration metrics, which vary by over an order of magnitude across different regions. A discernible correlation exists where higher institutional scale and output positively relate to productivity but inversely to citation depth. This indicates that an increase in publication volume does not always translate into proportional impact. The future growth and influence of this field will largely depend on whether high-output regions can effectively convert their extensive research into long-term impact through more diversified and robust international collaborations. In essence, while global engagement in sustainable construction and green infrastructure research is expanding, its overall bibliometric structure remains asymmetric and hierarchical. This configuration both propels rapid knowledge accumulation and highlights vulnerabilities regarding global research equity and balanced impact.

8. CONCLUSION

This bibliometric analysis of 19,991 Scopus-indexed publications (2025–2026) on sustainable construction materials and green infrastructure reveals a rapidly growing yet structurally uneven field. The dataset, spanning 2,011 sources and 54,650 authors, reflects strong global engagement but pronounced disparities across journals, institutions, and regions. Despite the high collaboration index (2.7 authors per paper), the average citation rate of 1.51 and strong Bradford concentration indicate a maturing yet highly centralized research ecosystem. At the journal level, output is dominated by Sustainability (944 papers), while Journal of Cleaner Production and Construction and Building Materials achieve superior impact metrics (h = 12 and 11, respectively). This imbalance between productivity and influence highlights a clear quantity–quality variance, where open-access, high-volume venues drive dissemination while selective journals shape long-term citation impact. Similarly, institutional productivity is heavily concentrated—Tsinghua University (357 papers) and Tongji University (266) far outpace peers—underscoring Asia's leadership in sustainable engineering research. Geographically, China leads with 5,241 corresponding-author papers and 9,078 total citations, yet its multi-country collaboration rate (25.2%) lags behind more internationally networked nations such as Australia (64.7%) and Germany (33.9%). These collaboration gradients, varying by more than thirtyfold between countries, explain much of the global citation variance. Nations with

extensive international partnerships (Australia, Canada, Italy) achieve higher citation averages, while large domestic networks (China, India, USA) dominate publication counts but exhibit lower per-paper visibility. Overall, the results depict a research domain that is globally expansive but hierarchically structured—anchored by a few high-output journals and institutions, with significant regional disparities in impact and collaboration. The challenge moving forward lies in bridging this productivity–impact divide through diversified publishing strategies and stronger transnational partnerships. Such integration is essential to ensure that the accelerating momentum in sustainable construction translates not only into more papers, but into globally distributed innovation and measurable environmental impact.

Conflicts of Interest

Author declare no conflicts of interest.

Funding

Author, declare they have received no funding for this paper.

Acknowledgment

Non.

References

[1] H. D. Sharma, A. Sandhu, Y. B. H. Al-Rubaie, A. Nema, and R. K. A. Al-Hussein, "Sustainable materials for infrastructure development to revolutionize civil engineering," in *Sustainable Civil Infrastructures*, Cham, Switzerland: Springer International Publishing, 2025, p. 21, doi: 10.1007/978-3-031-84335-8_2.

[2] B. A. Manu, "Innovative construction materials: Advancing sustainability, durability, efficiency, and cost-effectiveness in modern infrastructure," *Int. J. Res. Publ. Rev.*, vol. 5, no. 12, p. 4987, Dec. 2024, doi: 10.55248/gengpi.5.1224.0215.

[3] A. A. Firoozi, A. A. Firoozi, D. O. Oyejobi, S. Avudaiappan, and E. S. Flores, "Emerging trends in sustainable building materials: Technological innovations, enhanced performance, and future directions," *Results Eng.*, vol. 24, p. 103521, Nov. 2024, doi: 10.1016/j.rineng.2024.103521.

[4] N. S. Grigg, "Stormwater management: An integrated approach to support healthy, livable, and ecological cities," *Preprints*, Jun. 2024, doi: 10.20944/preprints202406.1575.v1.

[5] D. G. Yılmaz, "Nature-based solutions for climate-resilient cities: A proposal of a model for successful implementation," *J. Des. Resil. Archit. Plan.*, vol. 4, no. 2, p. 189, Aug. 2023, doi: 10.47818/drarch.2023.v4i2092.

[6] M. T. Tiza, "Integrating sustainability into civil engineering and the construction industry," *J. Cem. Based Compos.*, vol. 4, no. 1, p. 1, Feb. 2023, doi: 10.36937/cebacom.2023.5756.

[7] C. R. Rusnak, "Sustainable strategies for concrete infrastructure preservation: A comprehensive review and perspective," *Infrastructures*, vol. 10, no. 4, p. 99, Apr. 2025, doi: 10.3390/infrastructures10040099.

[8] M. Abate, A. C. J. Evangelista, and V. W. Y. Tam, "Global research trends in performance-based structural design: A comprehensive bibliometric analysis," *Buildings*, vol. 15, no. 3, p. 363, Jan. 2025, doi: 10.3390/buildings15030363.

[9] X. Li, J. Xu, and Y. S. Su, "Research status and emerging trends in green building materials based on bibliometric network analysis," *Buildings*, vol. 15, no. 6, p. 884, Mar. 2025, doi: 10.3390/buildings15060884.

[10] T. Chen, M. Wang, J. Su, R. M. A. Ikram, and J. Li, "Application of Internet of Things (IoT) technologies in green stormwater infrastructure (GSI): A bibliometric review," *Sustainability*, vol. 15, no. 18, p. 13317, Sep. 2023, doi: 10.3390/su151813317.

[11] N. Donthu, S. Kumar, D. Mukherjee, N. Pandey, and W. M. Lim, "How to conduct a bibliometric analysis: An overview and guidelines," *J. Bus. Res.*, vol. 133, pp. 285–296, May 2021, doi: 10.1016/j.jbusres.2021.04.070.

[12] W. M. Lim, S. Kumar, and N. Donthu, "How to combine and clean bibliometric data and use bibliometric tools synergistically: Guidelines using metaverse research," *J. Bus. Res.*, vol. 182, p. 114760, Jun. 2024, doi: 10.1016/j.jbusres.2024.114760.