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The Role of Green Innovation in Achieving Sustainable Development: Bibliometric Analysis

دور الابتكار الأخضر في تحقيق التنمية المستدامة: تحليل ببليومتري

***Ikhlef Djamel Eddine**
University of Continuing Education, Algeria
djameleddine.ikhlef@univ-tlemcen.dz

Hasrouri Lotfi
University of Batna 1, Algeria,
lotfi.hasrouri@univ-batna.dz

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Abstract : Green innovation is essential for balancing economic growth with environmental protection. This bibliometric study maps the field's intellectual and geographical structure by analyzing 1,997 Scopus-indexed articles from 2011 to 2025 using VOSviewer.

Findings reveal exponential growth in scientific output, particularly post-2021, with China leading in productivity and international collaboration. The Journal of Cleaner Production holds the highest citation impact. Keyword analysis shows that green innovation and sustainable development increasingly intersect with environmental regulation, green finance, ESG performance, digital transformation, and green technology. Ultimately, the field has evolved from a niche environmental topic into a strategic, multidisciplinary domain shaping future research, policy, and business strategies.

Key words: Green Innovation; Sustainable Development; Bibliometric Analysis; Scopus; VOSviewer; Environmental Sustainability; Economic Eevelopment.

JEL classificationcodes:*Q55, Q56, O33, O44, C88*

Corresponding author

1. Introduction.

Over the past few years, green innovation has emerged as an important research area (Takalo et al., 2020). These mounting environmental problems have highlighted the need for new paradigms that integrate economic development with environmental protection. In this framework, green innovation is proposed as a type of innovation that consists of new or improved products to minimise environmental impacts and increasing efficient use of resources through processes, technologies and practices ani et al., 2024; Takalo et al., 2020). Hence, green innovation is one of the most important responses to environmental issues while facilitating economic activity. Green innovation is somewhat related to sustainable development in a broader sense. Sustainable development aims to meet the needs of present and future generations while pursuing economic, social and environmental objectives together .In(Transforming our world: the 2030 Agenda for Sustainable Development | Department of Economic and Social Affairs, s. d.) this context, green innovation can contribute to the prevention of environmental pollution by improving resource use efficiency and promoting clean production. In addition, environmental innovation can yield economic benefits and enhance competitiveness while minimizing environmental stress (Porter &Linde, 1995). Therefore, green innovation plays a key role in mediating the relationship between innovation activities and sustainable development goals.

In recent years, the relationship between green innovation and sustainable development has received increasing academic attention. This growing interest reflects the need for innovative solutions to climate change, environmental pollution, resource depletion, and other sustainability challenges. Moreover, green innovation is increasingly connected with several research topics, including environmental regulation, green finance, digital transformation, corporate sustainability, and environmental performance(Rahmani et al., 2024; Takalo et al., 2020). Hence, research on green innovation and sustainable development has developed into a broad and multidisciplinary field.

Despite the growing number of studies, the literature on green innovation and sustainable development remains broad and dispersed across different disciplines, countries, and research themes. Previous studies have examined different aspects of green innovation and

sustainability. However, the rapid growth of this literature creates a need for a systematic mapping of its development and research structure. Such an analysis can provide a clearer view of publication trends, major contributors, geographical patterns, and dominant research themes. Bibliometric analysis is particularly useful for examining large volumes of scientific literature and identifying the development and emerging areas of a research field (Donthu et al., 2021). Moreover, bibliometric visualization can reveal relationships among authors, countries, and keywords. Therefore, combining bibliometric analysis with network visualization provides a structured approach to understanding the development of research on green innovation and sustainable development.

The objective of this study is to analyze the trends and structure of publications on green innovation and sustainable development using bibliometric analysis. The study also visualizes the main patterns and relationships within this research field using VOSviewer, a software tool developed for constructing and visualizing bibliometricnetworks(Van Eck &Waltman, 2010) . Data were obtained from the Scopus database and cover the period from 2011 to 2025. Accordingly, this study seeks to answer the following research questions:

- **Q1:**What is the distribution of Green Innovation and Sustainable Development publications in the years 2011–2025?
- **Q2:** Q1:What are the most relevant journals and authors in Green Innovation and Sustainable Development research?
- **Q3:**What are the most significant countries in Green Innovation and Sustainable Development research?
- **Q4:**What are the primary research keywords in Green Innovation and Sustainable Development research?
- **Q5:**What is the most important subject area associated with Green Innovation and Sustainable Development research?

2. Materials and Methods

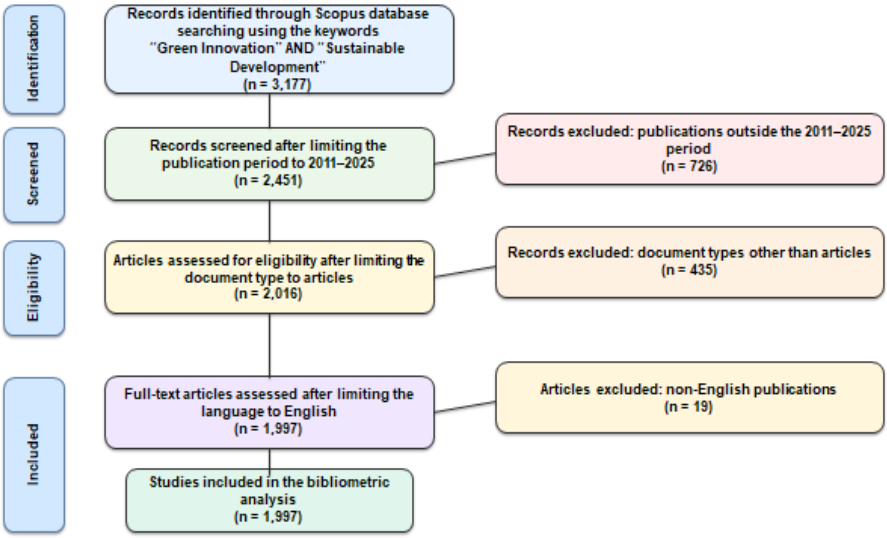
This study employed bibliometric analysis within a systematic literature review (SLR) framework to examine the scientific literature on green innovation and sustainable development. Bibliometric analysis provides a systematic approach for examining large volumes of scientific publications and identifying the structure and development of a research field(Donthu et al., 2021). The review process followed the Preferred Reporting Items for Systematic

Reviews and Meta-Analyses (PRISMA) guidelines. PRISMA supports transparent and comprehensive reporting of the processes used to identify, screen, and select studies for systematic reviews (Page et al., 2021). Accordingly, the selection procedure involved four main stages: identification, screening, eligibility, and inclusion. The completestudyselectionprocessispresented in Fig. 1.

The Scopus database was used as the bibliographic source for data collection. Scopus provides broad coverage of peer-reviewed scientific literature and is commonly used as a data source for bibliometricstudies(Donthu et al., 2021). Records were identified using search terms related to "Green Innovation" and "Sustainable Development." The retrieved records were then screened according to the predefined scope and eligibility criteria of the study. The final dataset covered publications from 2011 to 2025 and was used to address the five research questions. These questions focused on annual publication trends, the most relevant journals and authors, the most significant countries, keyword co-occurrence patterns, and the distribution of publications across subject areas. The identification, screening, eligibility, and inclusion procedures are summarized in the PRISMA flow diagram (Fig. 1).

Following data collection and screening, VOSviewer was used for bibliometric network analysis and visualization. VOSviewer is a software tool designed to construct and visualize bibliometric networks and to examine relationships among different bibliographic entities(Van Eck &Waltman, 2010). In this study, VOSviewer was used primarily to analyze keyword co-occurrence and international co-authorship networks. In the keyword analysis, the size of each node represents the occurrence of a keyword, while links indicate co-occurrence relationships between keywords. Similarly, in the country co-authorship analysis, links represent research collaboration among countries. In addition, descriptive analysis and graphical representations were used to summarize annual publication output, leading journals and authors, productive countries, and subject-area distribution.

Fig 1. The systematic literature review process using the PRISMA statement template based on four phases that are identification, screening, eligibility and included

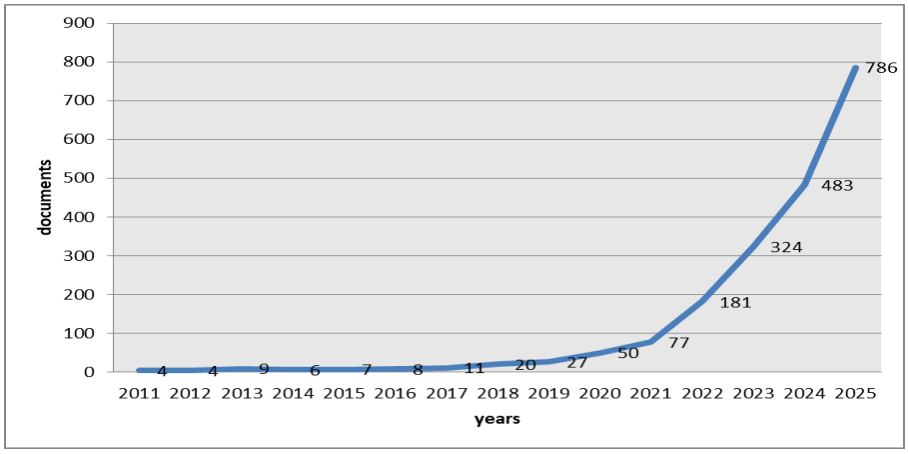


Source: Developed by the researchers based on the PRISMA statement

3. Results.

3.1. Research question 1. This study sought to examine the evolution of research on Green Innovation and Sustainable Development. The first finding answers the first research question, which concerns the distribution of publications between 2011 and 2025. As shown in **Fig. 2**, there was a clear increase in the number of documents produced over this 15-year period. Only 4 documents were published in 2011, compared with 786 documents in 2025. Scientific production remained relatively low between 2011 and 2017, ranging from 4 to 11 documents annually, before increasing to 20 documents in 2018, 27 in 2019, 50 in 2020, and 77 in 2021. A substantial increase was observed from 2022 onwards, with publications rising from 181 in 2022 to 324 in 2023 and 483 in 2024, before reaching the highest level of 786 documents in 2025. Overall, the results demonstrate a strong and accelerating growth in scientific interest in Green Innovation and Sustainable Development, particularly during the most recent years of the study period.

Fig 2.Annual scientific production in green innovation and sustainable development research (2011–2025).



Source: Developed by the authors based on data extracted from Scopus (2011–2025).

3.2. Research question 2. The second research question sought to identify the most relevant journals and authors in Green Innovation and Sustainable Development research. Figure 3 presents the ten most relevant journals in this research field in terms of total publications (TP). The Scopus database was used to identify the leading journals contributing to the field. Detailed information on these journals, including total publications (TP), total citations (TC), CiteScore 2025, the most cited article, times cited, and publisher, is presented in **Table 1.**

Table1: The 10 Most Relevant Journals in Green Innovation and Sustainable Development Research

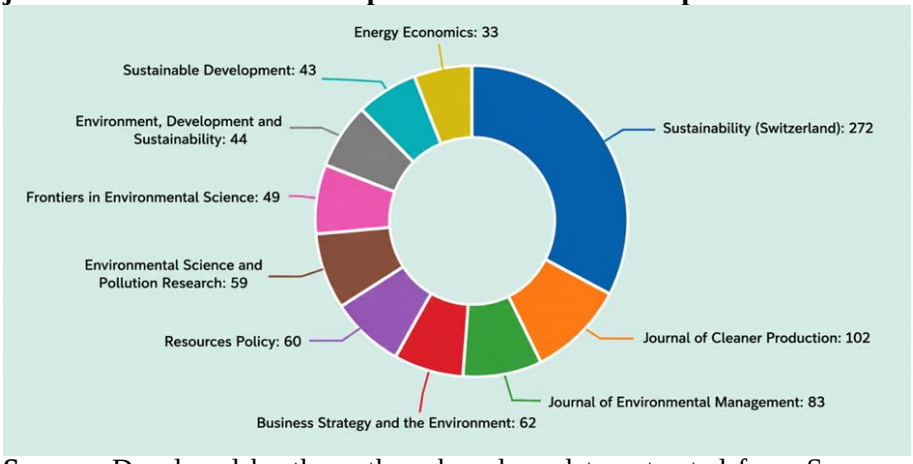
Journal	TP	TC	Citation Score 2025	Most cited article (Reference)	Times Cited	Publisher
Sustainability (Switzerland)	272	5327	8.9	Heavy Metal Pollution in Coastal Environments: Ecological Implications and Management Strategies: A Review	194	Multidisciplinary Digital Publishing Institute (MDPI)
Journal of	102	1461	21.3		140	Elsevier

Cleaner Production		9		Green and low-carbon matrices for Engineered/ Strain-Hardening Cementitious Composites (ECC/SHCC): Toward sustainable and resilient infrastructure		
Journal of Environmental Management	83	3544	13.9	Towards organic collaborative governance for a more sustainable environment: Evolutionary game analysis within the policy implementation of China's net-zero emissions goals	85	Elsevier
Business Strategy and the Environment	62	9255	23.8	A PRISMA-Based Systematic Review on Economic, Social, and Governance Practices: Insights and Research Agenda	94	John Wiley & Sons
Resources Policy	60	1915	20.3	Green taxes innovation and energy imports in advancing renewable transitions in developing countries	38	Elsevier
Environmental Science and Pollution	59	2036	12.1	Microplastics in aquatic systems: A	99	Springer Nature

Research				comprehensive review of its distribution, environmental interactions, and health risks		
Frontiers in Environmental Science	49	778	9.2	Advances in machine learning for the detection and characterization of microplastics in the environment	53	Frontiers Media S.A.
Environment, Development and Sustainability	44	718	11.6	Green hydrogen as a source of renewable energy: a step towards sustainability, an overview	128	Springer Nature
Sustainable Development	43	2026	13.6	AI-driven adaptive learning for sustainable educational transformation	446	John Wiley & Sons
Energy Economics	33	2025	21.8	How does green industrial policy affect corporate green innovation? Evidence from the green factory identification in China	90	Elsevier

Source: Developed by the authors based on data extracted from Scopus (2011–2025).

Fig. 3 The donut chart showing The 10 Most Relevant Authors in Green Innovation and Sustainable Development according to total publications. The indicator (text: number), text used represents journal name and number represents number of total publications



Source: Developed by the authors based on data extracted from Scopus (2011–2025).

As shown in Table 1 and Fig. 3, Sustainability (Switzerland) was the most productive journal, with 272 publications and 5,327 citations, followed by the Journal of Cleaner Production, with 102 publications and 14,619 citations, and the Journal of Environmental Management, with 83 publications and 3,544 citations. Although Sustainability (Switzerland) ranked first in terms of publication output, the Journal of Cleaner Production recorded the highest total number of citations among the ten journals, indicating its substantial scholarly influence in the field. Business Strategy and the Environment, with 62 publications and 9,255 citations, also demonstrated a strong citation impact and recorded the highest CiteScore (23.8) among the journals listed in Table 1.

In terms of highly cited contributions, the most cited article among the publications reported in Table 1 was "AI-driven adaptive learning for sustainable educational transformation," published in Sustainable Development, with 446 citations. This was followed by "Heavy Metal Pollution in Coastal Environments: Ecological Implications and Management Strategies: A Review," published in Sustainability (Switzerland), with 194 citations, and "Green and low-carbon matrices for Engineered/Strain-Hardening Cementitious Composites (ECC/SHCC): Toward sustainable and resilient infrastructure," published in the Journal of Cleaner Production, with 140 citations. Overall, the results reveal that the literature on Green Innovation and Sustainable Development is disseminated across journals covering sustainability, environmental management, cleaner production, environmental science, resource policy, and energy

economics.Research Question 2 also sought to identify the most relevant authors in Green Innovation and Sustainable Development research. The ten leading authors were identified using the Scopus database. **Figure 4** presents their citation performance, while Table 2 provides detailed information on each author, including the year of first publication, total publications (TP), h-index, total citations (TC), current affiliation, and country.

As shown in Table 2, **Chunping Chang** was the most productive author within the analyzed dataset, with **13 publications**, followed by **Boqiang Lin** with **11 publications** and **ArshianAslam Sharif** with **10 publications**. However, citation-based analysis reveals a different pattern of scholarly influence. **Boqiang Lin**, affiliated with Xiamen University, China, recorded the highest total number of citations (**53,220**) and the highest h-index (**118**) among the ten authors. He was followed in total citations by **Yu Hao** (**24,417 citations; h-index = 85**), **ArshianAslam Sharif** (**21,328 citations; h-index = 81**), and **MuhamamdHamzaIrfan** (**19,828 citations; h-index = 81**).

Table 2. The 10 Most Relevant Authors in Green Innovation and Sustainable Development Research

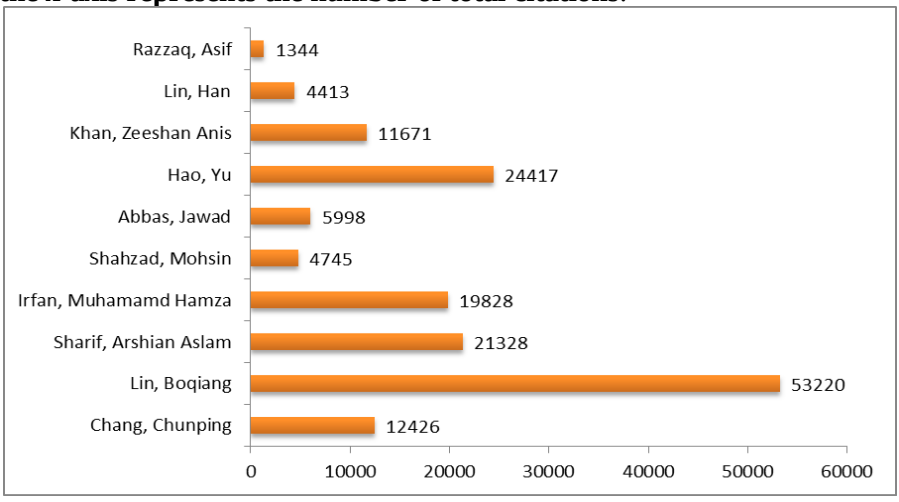
Author	Year of 1st publication	TP	h-index	TC	Current affiliation	Country
Chang, Chunping	2005	13	63	12426	Shih Chien University, Taipei, Taiwan	Taiwan
Lin, Boqiang	2010	11	118	53220	Xiamen University , Xiamen, China	China
Sharif, ArshianAslam	2016	10	81	21328	Sunwav University, Sunwav Citv, Malaysia	Malaysia
Irfan, MuhamamdHamza	2014	8	81	19828	Shandong Management University, Jinan, China	China
Shahzad, Mohsin	2019	8	30	4745	Liaoning Normal University, Dalian, China	China
Abbas, Jawad	2019	7	61	5998	University of Central Punjab, Lahore, Pakistan	Pakistan
Hao, Yu	2011	7	85	24417	School of Economics, Beijing Institute	China

					of Technology, Beijing, China	
Khan, ZeeshanAnis	2018	7	86	11671	Tsinghua University, Beijing, China	China
Lin, Han	2002	7	38	4413	Nanjing Audit University, Nanjing, China	China
Razzaq, Asif	2020	7	65	1344	CAREC Institute, Urumqi, China	China

Source: Developed by the authors based on data extracted from Scopus (2011–2025).

Figure 4 further highlights the considerable variation in citation impact among the leading authors. While Chunping Chang ranked first in terms of the number of publications related to the analyzed research field, Boqiang Lin exhibited substantially greater overall citation impact. Moreover, the geographical distribution of the authors indicates a strong contribution from **China**, with six of the ten authors currently affiliated with Chinese institutions, alongside researchers affiliated with institutions in Taiwan, Malaysia, and Pakistan. These findings suggest that both research productivity and scholarly influence in Green Innovation and Sustainable Development are particularly concentrated among authors and institutions in the Asian research context

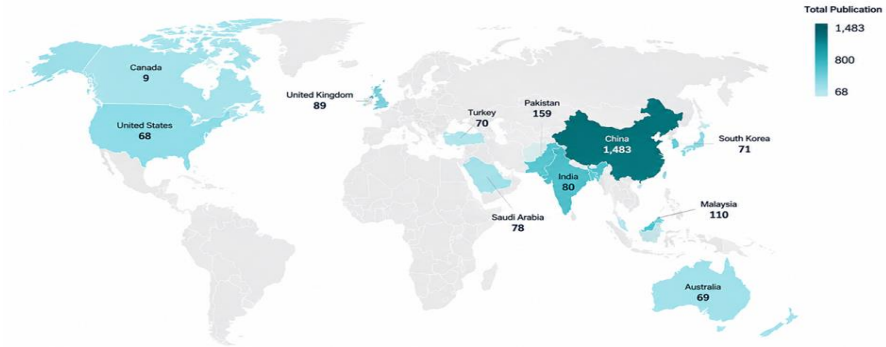
Fig 4.The bar graph shows the 10 most productive authors in Green Innovation and Sustainable Development research according to total citations (TC). The y-axis represents the names of the authors, while the x-axis represents the number of total citations.



Source: Developed by the authors based on data extracted from Scopus (2011–2025).

3.3.Research Question 3. The third research question sought to identify the countries with the most significant contributions to research on Green Innovation and Sustainable Development.

Fig 5. Geographical distribution of the top 10 most productive countries in Green Innovation and Sustainable Development based on total publications.



Source: Developed by the authors based on data extracted from Scopus (2011–2025).

Figure 5 presents a geographical map visualizing the most productive countries in this research area in terms of total publications (TP), based on data retrieved from the Scopus database. **Table 3** provides a summary of the top ten most productive countries in Green Innovation and Sustainable Development research. The criteria used for the analysis include Rank, Country, TP, and Most Significant Academic Institution.

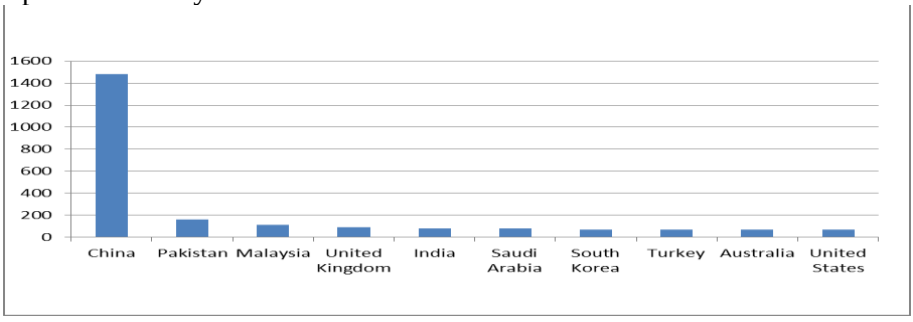
Table 3.Top 10 Most Productive Countries and Their Leading Academic Institutions in Green Innovation and Sustainable Development

Rank	Country	TP	Most significant academic institution
1	China	1483	Beijing Institute of Technology, Beijing, China
2	Pakistan	159	ILMA University, Karachi, Pakistan
3	Malaysia	110	University Putra, Selangor, Malaysia
4	United Kingdom	89	WUniversity of East Anglia, United Kingdom
5	India	80	Amity University, India
6	SaudiArabia	78	Princess NourahbintAbdulrahman University, Saudi Arabia
7	South Korea	71	Yonsei University, South Korea
8	Turkey	70	Near East University. Turkey
9	Australia	69	University of Newcastle Australia
10	United States	68	Kansas State University, United States

Source: Developed by the authors based on data extracted from Scopus (2011–2025).

As shown in **Table 3**, the most productive country in Green Innovation and Sustainable Development research was China, with a total of 1,483 publications, with the School of Management and Economics, Beijing Institute of Technology being its leading academic institution in this research area. China was followed by Pakistan, with a total of 159 publications, with the Faculty of Management Sciences, Department of Business Administration, ILMA University being its leading academic institution. Malaysia ranked third, with a total of 110 publications, and the Department of Software Engineering and Information System, Faculty of Computer Science and Information Technology, Universiti Putra Malaysia was identified as its leading academic institution. The United Kingdom ranked fourth with 89 publications, followed by India with 80 publications and Saudi Arabia with 78 publications. The remaining countries among the top ten were South Korea, Turkey, Australia, and the United States, with 71, 70, 69, and 68 publications, respectively. Overall, China exhibited a substantially higher level of research productivity than the other countries, highlighting its prominent contribution to Green Innovation and Sustainable Development research.The study then compared the number of publications produced by each of the top ten countries, which are portrayed using a bar chart to provide a clearer view of their research productivity. As illustrated in **Fig. 6**, China recorded the highest number of publications (1,483), followed by Pakistan (159), Malaysia (110), and the United Kingdom (89). India and Saudi Arabia produced 80 and 78 publications, respectively, while South Korea, Turkey, Australia, and the United States completed the list of the ten most productive countries. The substantial difference between China and the remaining countries further demonstrates China's dominant position in terms of publication output in this research field.

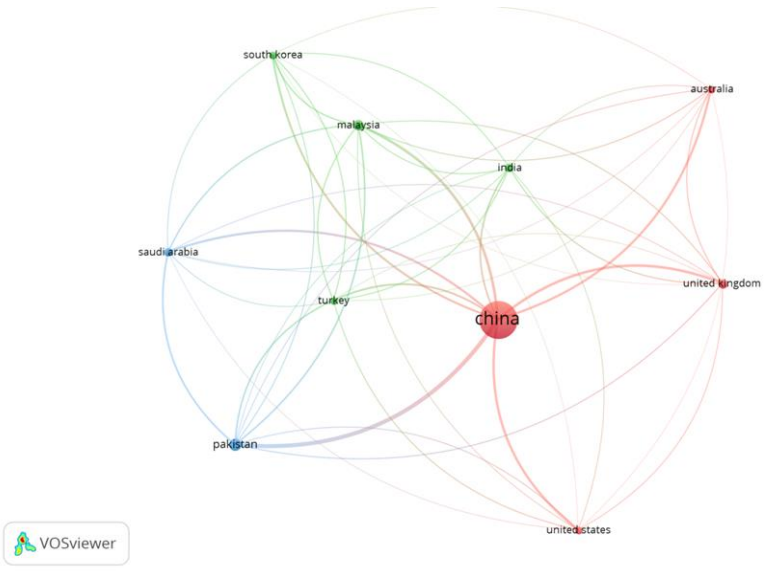
Fig. 6 The bar graph showing number of publications produced according to country. The y-axis represents number of publications and x-axis representscountry name**.**



Source: Developed by the authors based on data extracted from Scopus (2011–2025).

Next, this study examined the co-authorship relationships among the top ten most productive countries in Green Innovation and Sustainable Development research using VOSviewer software. As shown in Fig. 7, China occupies the most prominent position in the co-authorship network and maintains collaborative relationships with several of the other leading countries. The network also demonstrates international research collaboration among Pakistan, Malaysia, the United Kingdom, India, Saudi Arabia, South Korea, Turkey, Australia, and the United States. In the visualization, the size of each circle represents the number of publications associated with a country, while the lines connecting countries represent co-authorship relationships. The thickness of the links reflects the strength of collaboration between countries, and the different colors indicate distinct clusters of collaborating countries. Overall, the network illustrates the interconnected nature of international research collaboration in the field of Green Innovation and Sustainable Development.

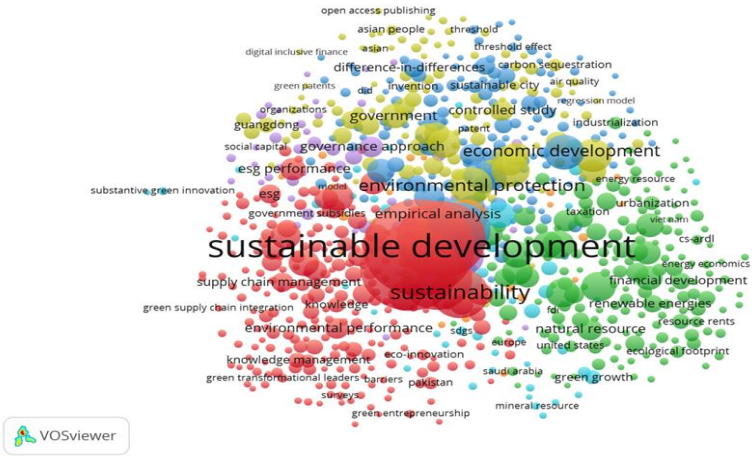
Fig. 7.A map based on the co-authorship relationships among the top 10 countries. The lines linking the countries represent co-authorship relationships with other countries. The size of eachcirclerepresents the number of publications



Source: Developed by the authors based on data extracted from Scopus (2011–2025).

3.4.Research Question 4. The fourth research question was about the primary research keywords used in green innovation and sustainable development research. This study examined the co-occurrence of all keywords in the data associated with green innovation and sustainable development. Figure 8 is a map based on the co-occurrence relationships of all keywords in the Scopus database. The keyword that had the highest co-occurrence (Oc) was "Sustainable Development", with 1,259 occurrences and a total link strength of 13,922, followed by "Green Innovation" (Oc = 974; total link strength = 8,448). Other keywords with high co-occurrence included "Green Innovations" (Oc = 508), "Green Economy" (Oc = 414), and "Sustainability" (Oc = 335). These results demonstrate the central position of sustainable development and green innovation within the overall keyword network and their strong connections with other research themes**.**

Fig. 8.A map based on the co-occurrence relationships among all keywords in Green Innovation and Sustainable Development. The lines linking the keywords represent their co-occurrence relationships with other keywords. The size of eachcirclerepresents



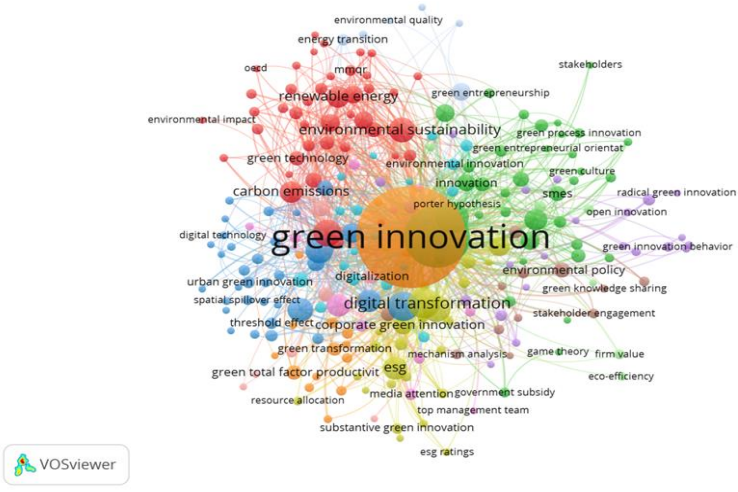
Source: Developed by the authors based on data extracted from Scopus (2011–2025).

The co-occurrence of author keywords was also analyzed, as mapped in **Fig. 9**. The keyword with the highest occurrence was **"Green Innovation"**, with **970 occurrences** and a **total link strength of 1,666**, followed by **"Sustainable Development" (Oc = 352; total link strength = 668)** and **"Sustainability" (Oc = 90; total link**

strength = 197). Other prominent author keywords included **"Environmental Regulation" (Oc = 80; total link strength = 162)**, **"Green Finance" (Oc = 69; total link strength = 153)**, **"ESG Performance" (Oc = 69; total link strength = 119)**, **"Green Technology Innovation" (Oc = 61; total link strength = 102)**, and **"Environmental Sustainability" (Oc = 60; total link strength = 131)**. Overall, the author keyword network confirms that **green innovation** constitutes the dominant research theme, closely interconnected with sustainable development, sustainability, environmental regulation, green finance, and other emerging environmental and technological themes.

3.5.Research Question 5. To answer the fifth research question, which sought to identify the most important subject areas contributing to research on **green innovation and sustainable development**, the publications were analyzed according to their subject areas. As demonstrated in the figure, **Environmental Science** represented the largest share of publications, accounting for **22.6%**, indicating that it is the most relevant subject area in this research field. This was followed by **Social Sciences (16.0%)**, **Energy (13.3%)**, **Business, Management and Accounting (11.9%)**, and **Economics, Econometrics and Finance (10.5%)**. **Computer Science (7.9%)** and **Engineering (6.1%)** also made notable contributions.

Fig. 9 A map based on the relationship of co-occurrence with author keywords. The line linking each keyword represents the relationship between their co-occurrence with other author keywords. The size of the circle shows number of occurrence.



Source: Developed by the authors based on data extracted from Scopus (2011–2025).

The remaining subject areas accounted for comparatively smaller proportions, including **Decision Sciences (2.9%)**, **Mathematics (1.4%)**, **Psychology (1.3%)**, **Multidisciplinary (1.1%)**, **Agricultural and Biological Sciences (1.1%)**, and **Medicine (0.9%)**. Other areas each contributed less than 1%, including **Arts and Humanities (0.7%)**, **Earth and Planetary Sciences (0.7%)**, **Chemical Engineering (0.5%)**, **Biochemistry, Genetics and Molecular Biology (0.3%)**, and **Materials Science (0.3%)**. The smallest contributions came from fields such as **Physics and Astronomy, Chemistry, Pharmacology, Toxicology and Pharmaceutics, Immunology and Microbiology, Neuroscience, and Veterinary Science**. Overall, these findings demonstrate the multidisciplinary nature of research on green innovation and sustainable development, while highlighting the predominant role of Environmental Science, Social Sciences, Energy, and business-related disciplines.

5. Discussion

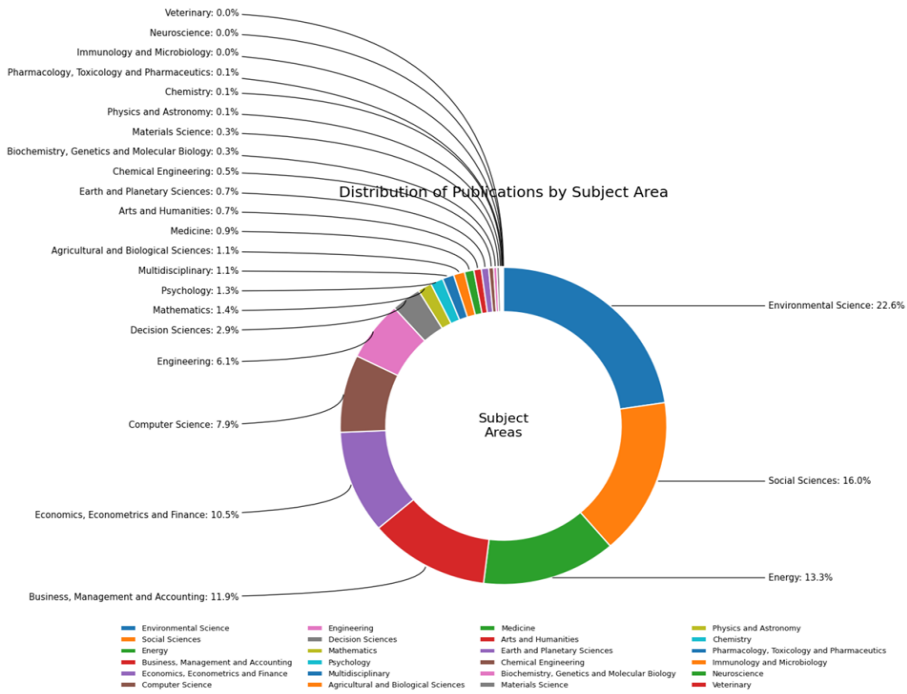
The results show a pronounced expansion of research on green innovation and sustainable development. Annual output increased from 4 publications in 2011 to 786 in 2025, with the sharpest acceleration after 2021.

This growth reflects the increasing policy and strategic importance of environmental innovation identified in earlier reviews (Rahmani et al., 2024; Takalo et al., 2020).

It also coincides with the consolidation of the 2030 Sustainable Development Goals and the Paris Agreement, which placed innovation, climate mitigation, sustainable production, and low-carbon investment at the center of international development agendas(United Nations Framework Convention on Climate Change, 2015)**.**

The post-2021 surge therefore suggests that green innovation has moved from a specialized environmental topic toward a mainstream research domain linked to climate policy, economic transformation, and corporate sustainability.

Fig. 10. Distribution of Publications on Green Innovation and Sustainable Development by Subject Area.



Source: Developed by the authors based on data extracted from Scopus (2011–2025).

The geographical distribution is highly concentrated. China accounts for 1,483 publications, followed by Pakistan (159), Malaysia (110), the United Kingdom (89), India (80), and Saudi Arabia (78). This dominance is consistent with China's extensive policy emphasis on industrial decarbonization, environmental regulation, green technology, and carbon-neutral development. Its dual-carbon strategy has institutionalized carbon peaking and neutrality as central components of national development planning. The author results reinforce this concentration: although Chunping Chang is the most productive author in the dataset, Boqiang Lin exhibits the highest citation impact among the leading authors, with 53,220 citations and an h-index of 118. At the same time, Fig. 7 demonstrates that China functions as a central collaboration node linking Pakistan, Malaysia, India, and other Asian countries with established research systems such as the United Kingdom, United States, and Australia. This indicates that China's dominance is accompanied by substantial international knowledge exchange rather than geographic isolation.

The keyword structure further demonstrates the maturation of the field. While broad concepts such as sustainable development, green innovation, green economy, and sustainability remain dominant, the author-keyword network increasingly emphasizes more specific mechanisms, including environmental regulation, green finance, ESG performance, green technology innovation, digital transformation, carbon emissions, and the Porter Hypothesis. This shift suggests that research has progressed from asking whether green innovation contributes to sustainability toward examining how it is financed, regulated, technologically enabled, and translated into measurable environmental outcomes. The prominence of the Porter Hypothesis is especially significant because it connects environmental regulation with innovation and competitiveness, challenging the conventional assumption that environmental protection necessarily imposes only economic costs(Porter &Linde, 1995).

Likewise, the growing presence of ESG and digital transformation indicates that green innovation is increasingly embedded within corporate governance, sustainable finance, and digitalization.

The subject-area distribution confirms the field's multidisciplinary character. Environmental Science accounts for 22.6% of publications, followed by Social Sciences (16.0%), Energy (13.3%), Business, Management and Accounting (11.9%), and Economics, Econometrics and Finance (10.5%). This disciplinary diversity reflects the multidimensional nature of green innovation: environmental science addresses ecological outcomes, energy research focuses on decarbonization, economics examines regulation and incentives, and management research evaluates corporate strategy and ESG integration. Digital and technological dimensions are additionally reflected in Computer Science and Engineering.

A final important finding concerns the difference between publication volume and citation influence. Sustainability (Switzerland) is the most productive journal with 272 publications, whereas the Journal of Cleaner Production has the highest citation total at 14,619 citations. Business Strategy and the Environment, despite publishing fewer articles, records the highest CiteScore in the dataset (23.8). This asymmetry reinforces the distinction between productivity and impact in bibliometric evaluation(Donthu et al., 2021). The results therefore indicate that broad multidisciplinary outlets facilitate dissemination, whereas more specialized journals may exert greater intellectual influence within the field.

6. Conclusion

This study mapped 1,997 Scopus-indexed articles published between 2011 and 2025 and addressed five dimensions of green innovation and sustainable development research: temporal development,

leading journals and authors, geographical concentration, keyword structure, and disciplinary composition. Publication output expanded rapidly, particularly after 2021; Sustainability led in publication volume, whereas the Journal of Cleaner Production led in citation impact; China dominated national productivity and occupied a central position in international collaboration; and green innovation and sustainable development formed the core of an increasingly diverse keyword network.

Overall, the evidence shows that green innovation has evolved from a relatively narrow environmental topic into a strategic interdisciplinary field connecting environmental regulation, green finance, ESG, digital transformation, energy transition, and corporate competitiveness. Environmental Science remains the dominant disciplinary base, but substantial contributions from social sciences, energy, management, and economics demonstrate that sustainable development increasingly requires integrated technological, institutional, and economic perspectives.

7. Implications and Future Directions

Academic implications. The study consolidates a fragmented literature and identifies a convergence among green innovation, ESG, green finance, and digital transformation. Future theoretical models should increasingly examine the joint influence of AI, Industry 4.0, financial mechanisms, and institutional pressures on green technological outcomes. Bibliometric mapping is particularly useful for revealing such structural relationships across rapidly expanding research fields (Donthu et al., 2021; Van Eck &Waltman, 2010).

Policy and managerial implications. Policymakers should combine well-designed environmental regulation with green finance, R&D incentives, and international research cooperation. Such complementary instruments may stimulate innovation while supporting environmental and economic objectives, consistent with the Porter Hypothesis(Porter &Linde, 1995)

Managers should similarly integrate green product and process innovation with ESG strategy, digital capabilities, and long-term competitiveness rather than treating sustainability solely as a compliance requirement.

Limitations. The study is based exclusively on Scopus and English-language articles, which may exclude relevant publications indexed elsewhere or published in other languages. In addition, citation indicators for 2024–2025 publications are affected by citation lag and should therefore be interpreted cautiously.

Future research agenda. Future studies should first use firm-level microdata from underrepresented regions, particularly Africa,

MENA, and Latin America, to test whether established green-innovation relationships generalize beyond Asian settings. Second, research should examine how AI, Industry 4.0, digital platforms, and data analytics influence green technology adoption and environmental performance. Third, longitudinal and quasi-experimental studies should evaluate the long-term effects of environmental regulation, green subsidies, carbon markets, and green-finance policies on both the quantity and quality of green innovation.

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