Advancing Sustainability with Eco-innovation and Environmental Impact in Engineering Through a Bibliometric Lens

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Abstract– This study presents a comprehensive bibliometric review of eco-innovation and sustainability within the engineering sector, emphasizing its pivotal role in minimizing environmental impacts and advancing sustainable development. Analyzing 768 publications from 2000 to 2024, sourced from Scopus and Web of Science, the review employs the PRISMA method and advanced bibliometric tools, including VOSviewer and Bibliometrix, to examine scientific production, collaboration networks, and thematic trends. The findings indicate exponential growth in research output, with significant contributions from China, the United Kingdom, and Italy, as well as notable institutions such as Delft University of Technology. Core themes such as sustainability, eco-innovation, and green innovation dominate the field while emerging topics like circular economy and eco-design point to new research directions. Finally, this review maps the current research landscape to identify critical opportunities for advancing eco-innovation within engineering. It serves as a valuable resource for researchers, policymakers, and industry leaders dedicated to promoting sustainability and addressing global environmental issues.

List of Abbreviations—LCA (Life Cycle Assessment), MCP (Multiple Country Publications), SCP (Single Country Publications), SDGs (Sustainable Development Goals), PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses), DEMATEL (Decision-Making Trial and Evaluation Laboratory), WoS (Web of Science).

Keywords—Eco-innovation, Sustainability, Bibliometric analysis, Circular economy, Environmental impact.

I. Introduction

Eco-innovation has emerged as a critical area of research due to its potential to address pressing global environmental challenges while simultaneously fostering sustainable economic development. By integrating technological advancements, organizational practices, and environmental stewardship, eco-innovation provides a multidimensional framework for achieving sustainable solutions. This concept is particularly relevant within engineering, where innovative practices are vital in minimizing environmental impacts, improving resource efficiency, and advancing long-term sustainability goals [1–7].

Previous studies, such as the bibliometric review conducted by Fatma and Haleem [8], have explored the relationship between eco-innovation and the United Nations Sustainable Development Goals (SDGs), emphasizing its broad implications across economic, social, and environmental dimensions. However, their analysis adopts a general interdisciplinary perspective without explicitly addressing the specific role of engineering. In contrast, the present study narrows its scope to examine eco-innovation within the engineering domain, providing a detailed analysis of technological advancements and their contributions to sustainability and environmental impact mitigation.

Expanding global economic activities has intensified the need to align engineering practices with sustainability objectives. For example, natural resources such as solar energy exemplify how eco-innovations can stimulate economic growth and reduce CO_2 emissions. Moreover, methodologies including life-cycle assessment (LCA), circular economy principles, and cleaner production strategies have proven effective in enhancing environmental performance. Nonetheless, several challenges persist—most notably, the heterogeneity of methodologies and the limited adoption of eco-innovative practices within engineering processes [9–23].

In order to address these gaps, this bibliometric review systematically examines research trends, thematic evolution, and key contributors in the intersection of eco-innovation and sustainability in engineering. Drawing upon data from the Scopus and Web of Science databases, the study analyzes a corpus of 768 articles published between 2000 and 2024. The Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) method [24–27], along with advanced bibliometric tools such as VOSviewer, Bibliometrix, and RStudio, are employed to evaluate scientific output, collaboration networks, and thematic development patterns [28–37].

Unlike prior reviews [8] that approach eco-innovation from broad interdisciplinary or policy-oriented perspectives, this study offers a focused bibliometric mapping centered on the engineering sector. Through the integration of a PRISMA-based methodology and sophisticated bibliometric techniques, the study delivers a more granular and sector-specific analysis of emerging research themes, collaborative structures, and existing gaps. This refined focus represents a novel contribution to the literature by highlighting the unique and strategic role of engineering in advancing sustainable innovation. By systematically synthesizing the available evidence, the review provides critical insights into the evolution of the field, identifies persistent challenges, and outlines future opportunities. These findings are intended to inform the development of targeted research agendas, support evidence-based policymaking, and promote the broader adoption of sustainable engineering practices—thereby contributing to the attainment of global sustainability objectives.

II. METHODOLOGY

In order to ensure transparency and reproducibility, a systematic approach guided by PRISMA standards was employed.

A. Search Strategy

The literature search was conducted using two prominent academic databases, Scopus and Web of Science. It focused on studies addressing eco-innovation, environmental impact, and sustainability in engineering. Although the core search query remained consistent across both platforms, adjustments were made to accommodate their specific indexing systems: *("eco-innovation" OR "Green innovation" OR "Sustainable innovation" OR "ecological innovation" OR "environmental innovation") AND ("environmental impact" OR "ecological impact" OR "sustainability" OR "Environmental footprint" OR "Ecological footprint" OR "Impact on the environment" OR "Environmental consequences").* In Scopus, the query was applied to the *TITLE-ABS-KEY* fields and restricted to the "Engineering" subject area. In Web of Science, the same terms were searched within the *Topic* field and limited to the "Engineering" research area. The search targeted English-language publications on engineering-related topics, covering 2000 to 2024.

Inclusion and exclusion criteria were established to ensure the selection of studies most relevant to the objectives of this bibliometric review. Eligible articles must be published in peer-reviewed journals, written in English, and explicitly address eco-innovation, environmental impact, or sustainability within the engineering context.

Conversely, articles were excluded if identified as duplicates during the initial screening or published outside the 2000–2024-time frame. Studies written in languages other than English, such as Spanish, Chinese, Russian, Italian, and Portuguese, were also excluded. Furthermore, non-research articles—including conference papers, book chapters, reviews, retracted publications, letters, and editorials—were deemed ineligible for analysis.

B. Screening and Selection Process

The screening and selection process comprised four stages, as outlined in the PRISMA Flowchart, Figure 1:

- *Identification:*
  A total of 1415 records were retrieved (891 from Scopus and 524 from Web of Science). After removing 281 duplicates, 1134 unique records remained for further screening.

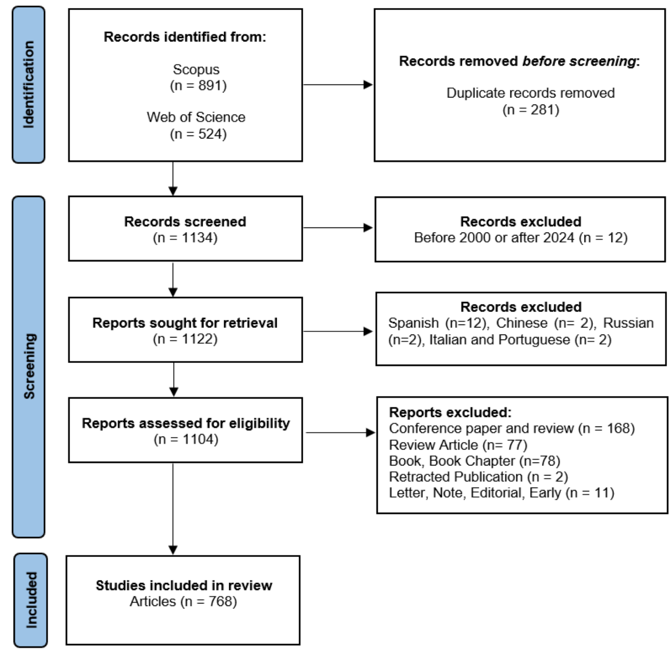

Figure 1: PRISMA Flowchart detailing the identification, screening, eligibility, and inclusion of studies for the bibliometric review.

- *Screening:*
  Titles and abstracts were reviewed, and 12 articles published outside the specified time frame (2000–2024) were excluded.
- *Eligibility:*
  The remaining 1122 records were evaluated for eligibility. Articles in non-English languages were excluded (18), along with 336 non-eligible document types, including conference papers, reviews, and book chapters.
- *Inclusion:*
  Following the final screening, 768 articles met the inclusion criteria and were selected for bibliometric analysis.

C. Screening and Selection Process

Key metadata from the included articles, including authorship, publication year, journal, citations, keywords, and affiliations, were extracted. The analysis used bibliometric tools such as *Bibliometrix* and *Biblioshiny* in RStudio and *VOSviewer* for network visualization. These tools facilitated the identification of trends, patterns, and relationships within the literature of the field.

III. RESULTS

The findings are presented in distinct subsections, covering the evolution of scientific output, thematic trends, network relationships, and geographic and institutional contributions. These insights collectively highlight the progression and current focus areas within the field.

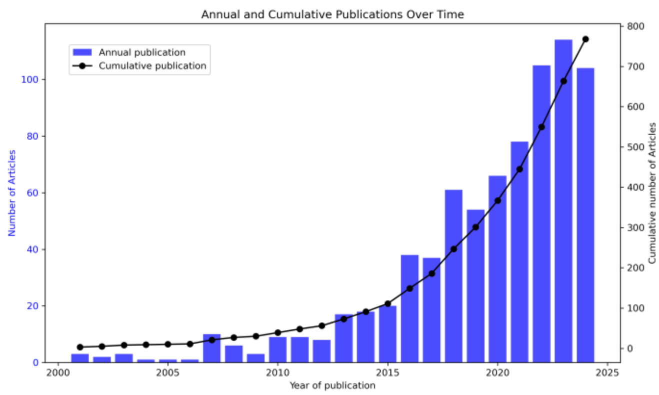

Figure 2: Annual and cumulative publication, illustrating the exponential growth in research output and cumulative trajectory in the domain.

A. Scientific Production Over Time

The dataset includes 1104 entries (before the exclusion and inclusion criteria), considering only documents in English. The majority are original research articles (70%). Conference and review papers account for 15% of the total, while review articles represent 7%. Books and book chapters also constitute 7%. The remaining contributions include retracted publications (0.2%) and other formats such as letters, notes, editorials, and early-access articles (1%). This study focuses specifically on the original research articles.

The analysis of scientific production from 2001 to 2024 demonstrates a significant increase in publications, highlighting the growing importance of eco-innovation and sustainability in engineering. As shown in Figure 2, annual publication rates have followed an exponential growth pattern, with notable peaks in 2022 (105 articles) and 2023 (114 articles). By 2024, the cumulative total reached 768 articles, reflecting sustained academic interest. This upward trend underscores the increasing recognition of eco-innovation and sustainability as crucial for addressing global environmental challenges.

B. Distribution of Scientific Production

The geographic distribution of scientific production in eco-innovation, environmental impact, and sustainability within engineering reveals notable disparities across regions. Figure 3 illustrates the global distribution of publications, highlighting a concentration of research activity in specific countries. China stands out as the leading contributor, with 416 publications, followed by the United Kingdom (156), Italy (131), Spain (128), and the United States (107). Other significant contributors include the Netherlands (88), Brazil (79), India (67), Germany (64), and France (57). These nations demonstrate robust research outputs, underscoring their commitment to integrating sustainable engineering practices in academic and industrial sectors.

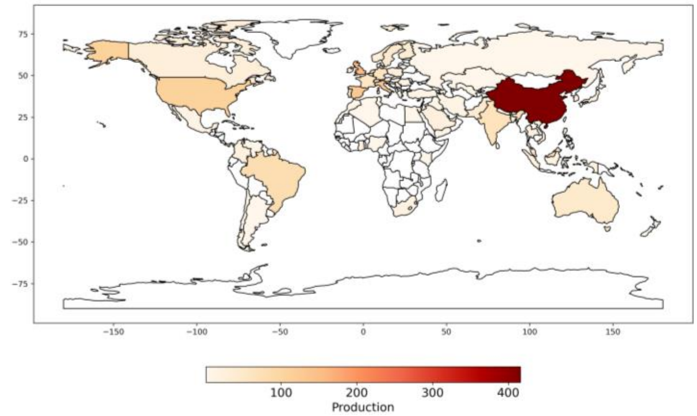

Figure 3: Country Production

Conversely, many regions, particularly Latin America (with Brazil being the most significant contributor with 79 publications), Africa, and smaller European and Asian countries, exhibit limited or negligible contributions. For example, nations such as Venezuela, Albania, and Kenya report only one publication each, underscoring the need for increased investment and international collaboration to address these disparities and promote more equitable participation in this critical field.

Table 1: Most Cited Countries

Country	Total Citations
China	8265
Spain	4956
Netherlands	3552
United Kingdom	2942
Italy	2187
Brazil	1446
Germany	1261
USA	1033
Sweden	880
France	864
Finland	846
Denmark	813
India	806
Canada	724

The global impact of research is further illustrated in Table 1, highlighting the countries with the highest total citations (TC). China leads with 8265 total citations, reflecting the breadth of its academic output. In contrast, despite producing fewer publications, China is followed by Spain (3552), the Netherlands (2942), and the United Kingdom (2855). These figures underscore the global influence of research outputs from these nations in advancing sustainability discussions and practices.

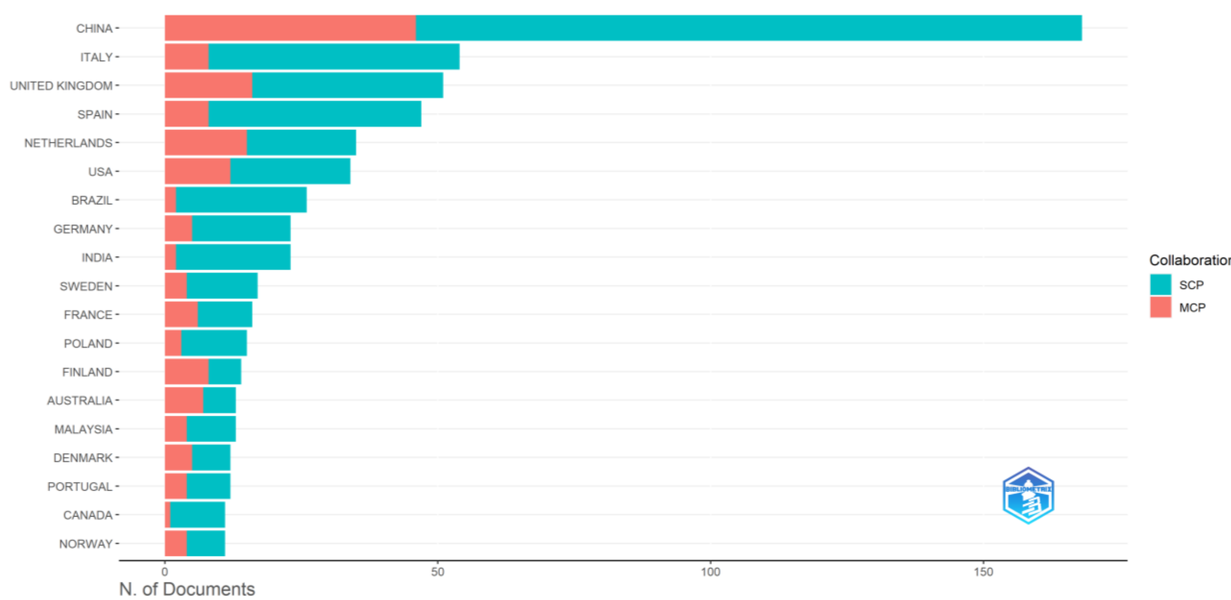

Figure 4:Corresponding Authors Countries

C. Authors, Corresponding Authors and International Collaboration

An additional layer of analysis examines the countries of the corresponding authors and the nature of their collaborative efforts. Figure 4 presents the number of articles attributed to corresponding authors by country, distinguishing between Single-Country Publications (SCPs) and Multiple-Country Publications (MCPs). This differentiation sheds light on the collaborative dynamics shaping global research in eco-innovation and sustainability. China leads with 168 articles authored by Chinese corresponding authors, of which 122 are SCPs and 46 are MCPs. The latter reflects a strong focus on domestic research collaboration, complemented by significant international partnerships. Similarly, Italy ranks second with 91 articles (68 SCPs, 23 MCPs), followed by the United Kingdom with 85 articles (54 SCPs, 31 MCPs) and Spain with 70 articles (55 SCPs, 15 MCPs). The Netherlands (53 articles; 41 SCPs, 12 MCPs) and the United States (51 articles; 36 SCPs, 15 MCPs) also display a balanced output between domestic and international collaborations.

On the other hand, Brazil stands out as a leader in Latin America, contributing 39 articles by Brazilian corresponding authors (29 SCPs, 10 MCPs), highlighting its regional prominence in sustainable engineering research. However, other Latin American countries show significantly lower outputs, underscoring regional disparities in research infrastructure and funding.

The distinction between SCPs and MCPs reveals broader trends in research collaboration. Countries like China and Brazil prioritize domestic collaborations, likely driven by national research agendas and funding strategies. In contrast, nations such as the United Kingdom and the Netherlands exhibit more MCPs, reflecting their integration into global research networks. These patterns underscore the need to balance local research capacity-building with international partnerships to advance sustainable engineering on a global scale.

On the other hand, the analysis of the most prolific authors in the research area highlights individual contributions shaping the research landscape. As illustrated in Figure 5, SALA S and TSENG M lead the field with eight publications each, followed by BOCKEN N with seven articles. Other notable contributors include WANG Y and ZHANG X, with six publications each, alongside ANGELIS-DIMAKIS A, CASTELLANI V, CHEN J, CHEN Y, and GOVINDAN K, who have each authored five articles. The temporal distribution of their research activity, depicted in Figure 6, provides further insights into the consistency of their contributions. For example, SALA S exhibited a productivity peak in 2017, publishing four articles that year, while TSENG M maintained a steady output between 2019 and 2021. BOCKEN N began contributing in 2012 and demonstrated consistent activity through 2021. These temporal patterns underscore the sustained efforts of leading authors to advance research in this field over time.

In a broader context, the significant presence of numerous authors contributing four or fewer articles highlights the collaborative and diverse nature of this research domain. Such diversity fosters multidisciplinary approaches, integrating perspectives from various fields to tackle the complex challenges associated with eco-innovation and sustainability in engineering. Therefore, the combined impact of consistent contributions from key authors and the collective efforts of a vast academic community underscores the dynamic and evolving nature of this research area. The field thrives on high-impact individual efforts and incremental advancements driven by broad, collaborative participation.

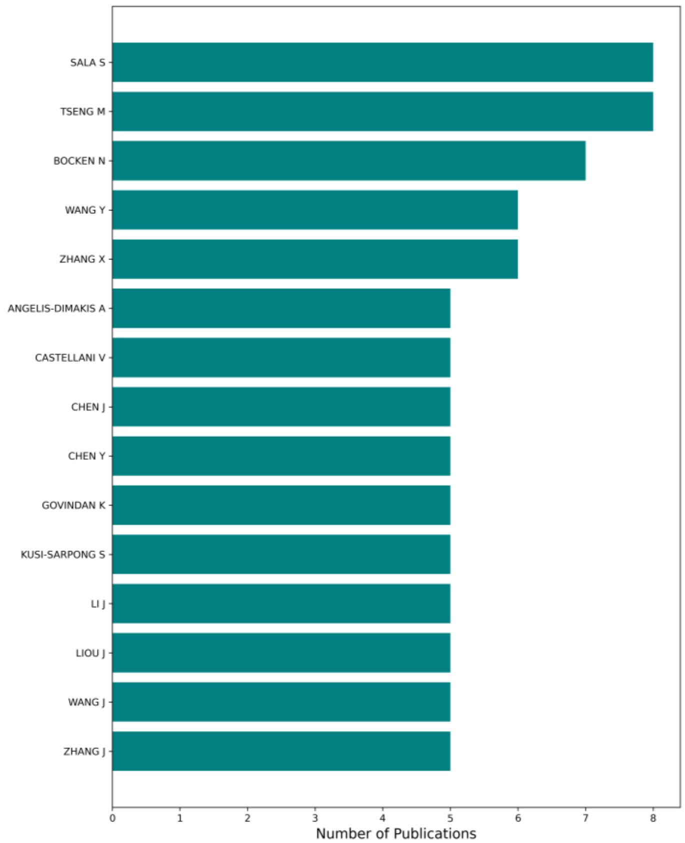

Figure 5: Author Publications

The analysis of the collaboration network among authors (Figure 7) reveals distinct clusters of research partnerships within the research area. This visualization underscores the interconnectedness and collective efforts of researchers in advancing knowledge in this area.

The most extensive collaboration cluster centers around SALA S, closely associated with CASTELLANI V and BALDASSARRI C, forming a cohesive co-authorship network. Another significant cluster includes ANGELIS-DIMAKIS A, ARAMPATZIS G, and ASSIMACOPOULOS D, illustrating focused collaborative contributions. Similarly, TSENG M is prominently linked with ALI M and BUI T, reflecting a targeted approach to specific research themes.

A broader and more diverse network is observed around WANG Y, who collaborates with multiple co-authors, including CHEN J, LIU L, and SONG M. This network highlights a multidisciplinary approach, integrating perspectives from various areas within sustainability and engineering.

Conversely, smaller and more isolated clusters, such as those of PRZYCHODZEN J and PRZYCHODZEN W or CARRILLO-HERMOSILLA J and PRIETO-SANDOVAL V, represent niche research areas with limited external collaboration. While these smaller networks contribute valuable specialized insights, their relative isolation underscores opportunities for broader engagement with the wider research community.

D. Relevant Sources and Affiliations

Figure 8 highlights the most productive journals in the field. The Journal of Cleaner Production is the top source, contributing 278 publications and underscoring its prominence in advancing sustainable production practices. Sustainability (Switzerland) ranks second with 96 publications, followed by Resources, Conservation, and Recycling with 25. Other notable contributors include Energies (20 publications), Sustainable Production and Consumption (17), and the International Journal of Production Economics (14).

Regarding journal quality, the Journal of Cleaner Production, Sustainability (Switzerland), and Resources, Conservation, and Recycling are all categorized as Q1 and Q2 journals, reflecting their high impact and rigorous peer-review processes. Additionally, Energies and Sustainable Production and Consumption are also classified as Q2 and Q1, respectively, in their respective categories, further demonstrating the prominence of these outlets within the field. The strong representation of Q1 and Q2 journals underscores the robust academic foundation supporting research in sustainable engineering.

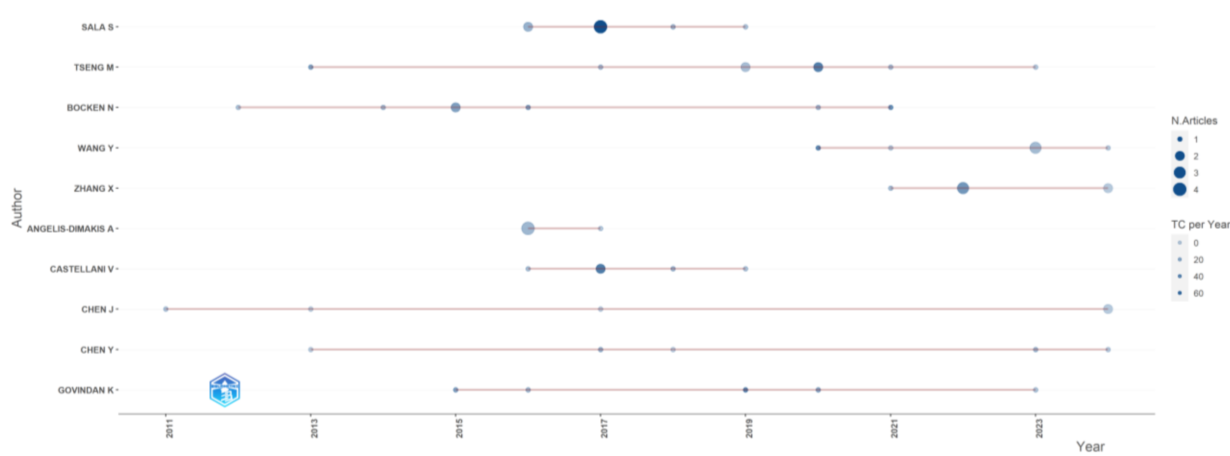

Figure 6: Authors Production Over Time

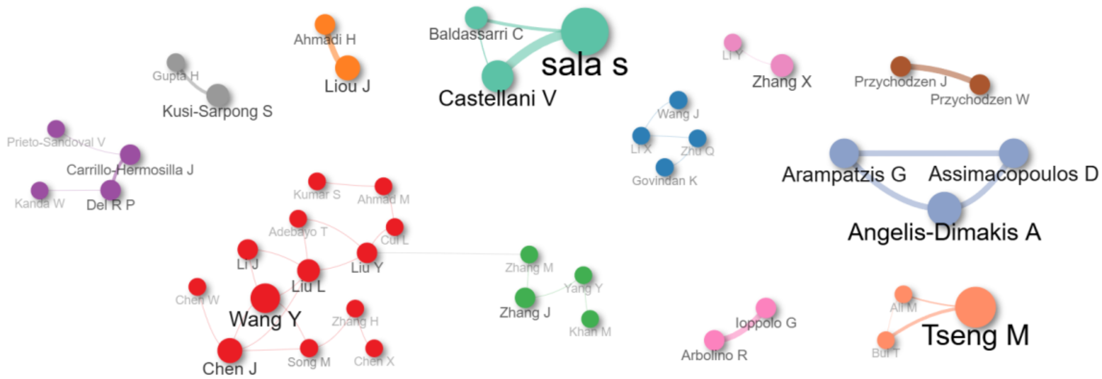

Figure 7: Collaboration Network

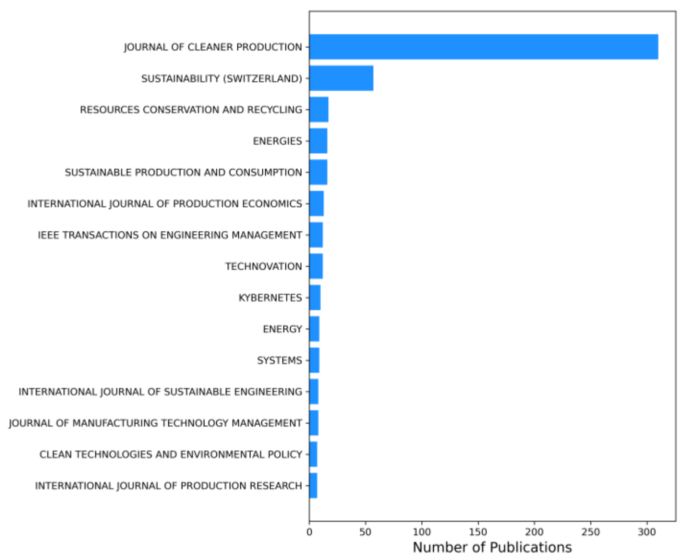

Figure 8: Relevant Sources

The dominance of high-quality journals not only highlights the scholarly rigor of this field but also emphasizes the importance of eco-innovation and sustainability as critical research priorities. These journals are essential platforms for disseminating advanced knowledge, fostering academic collaboration, and bridging the gap between research and practical applications.

Table 2 highlights the most influential affiliations contributing to eco-innovation and sustainability in engineering. Delft University of Technology leads with 16 publications, followed closely by Dalian University of Technology and the University of Castilla-La Mancha, each contributing 14 articles. Other prominent institutions include Linköping University and the University of Cambridge, with 13 publications each.

The high research output of these institutions reflects their strategic focus on sustainability and innovation. Moreover, their engagement in international collaborations fosters the integration of diverse perspectives, enabling them to address complex engineering challenges effectively. For example, the Delft University of Technology and the University of Cambridge, renowned for their strong engineering programs and multidisciplinary research initiatives, likely benefit from their robust infrastructure and global partnerships, contributing to their high productivity.

Table 2: Most Relevant Affiliations

Affiliations	**Articles**
Delft University of Technology	16
Dalian University of Technology, University of Castilla-La Mancha	14
Linköping University, University of Cambridge	13
Asia University, Jiangsu University, University Polytechnic of Valencia	11
University of Utrecht, Xi'an Jiaotong University	10
Aalborg University, Vrije University Amsterdam	9
Aalto University, China Medical University, Nanjing Audit University, National Taipei University of Technology, Norwegian University of Science and Technology, Shanghai Jiao Tong University, University Beira Interior, University Deusto, University Naples Parthenope, University São Paulo, University Southern Denmark, University Vaasa, Zhejiang Gongshang University	8

The global representation of affiliations underscores the widespread academic interest in eco-innovation and sustainability. However, the limited presence of institutions from developing countries highlights a significant gap, suggesting increased participation and collaboration opportunities to enhance global research equity. This analysis of key affiliations and sources underscores their pivotal roles in advancing sustainability discourse. By identifying these leading contributors, the study is a valuable resource for researchers seeking impactful publication venues and collaboration opportunities in this critical field.

E. Keyword Co-occurrence Networks

The keyword co-occurrence analysis offers valuable insights into the thematic structure of research in eco-innovation, sustainability, and environmental impact within engineering. Two primary keywords were examined: Author Keywords (provided directly by the authors) and Keywords Plus (algorithmically generated based on references in the analyzed articles). The resulting networks reveal the relationships and centrality of key concepts within the field.

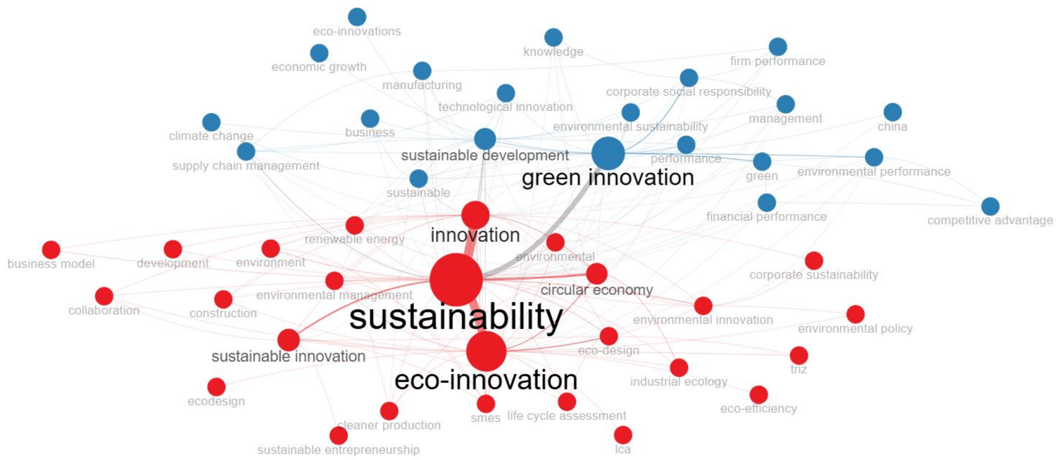

Figure 9: Author Keyword Co-occurrence Networks

The co-occurrence network of Author Keywords (Figure 9) identifies sustainability, eco-innovation, and green innovation as central, highly interconnected terms. These keywords act as thematic hubs, linking to secondary topics such as circular economy, environmental performance, and renewable energy. The prevalence of terms like innovation and sustainable development underscores the strong focus on integrating innovative practices into sustainability initiatives.

Additionally, smaller clusters within the network address specialized areas such as life cycle assessment (LCA), eco-efficiency, and corporate sustainability, reflecting niche interests within the broader field. These terms highlight the diverse applications and interdisciplinary approaches shaping sustainable engineering research.

On the other hand, the Keywords Plus co-occurrence network (Figure 10) provides a broader perspective by encompassing algorithmically derived terms that connect multiple articles. Similar to the Author Keywords network, sustainability and eco-innovation dominate the network. However, additional terms such as environmental impact, management, and performance gain prominence, emphasizing the operational and evaluative dimensions of sustainability within engineering. Distinct clusters in this network highlight themes like environmental management, energy efficiency, and policy, which blend theoretical insights with practical applications. Including terms like China and public policy suggests regional and policy-driven considerations that influence the literature.

Author Keywords often highlight specific and technical aspects of research, such as eco-design and environmental performance, while Keywords Plus captures broader themes and methodological approaches. These networks offer a nuanced perspective, illustrating the interplay between detailed technical discussions and overarching strategic objectives. Finally, the analysis of these co-occurrence networks underscores the multidisciplinary and interconnected nature of the field. By identifying thematic cores and their relationships, this approach maps the current state of research and reveals opportunities for future exploration. Notably, it highlights the potential to integrate emerging concepts, such as circular economy and sustainable entrepreneurship, into mainstream engineering practices, thereby advancing the field toward more comprehensive and innovative solutions.

F. *Three-Field Plot Analysis*

The Three-Field Plot, as shown in Figure 11, comprehensively visualizes the relationships between the most relevant journals, prolific authors, and frequently used keywords. This Sankey diagram provides valuable insights into the interconnected dynamics of the research ecosystem.

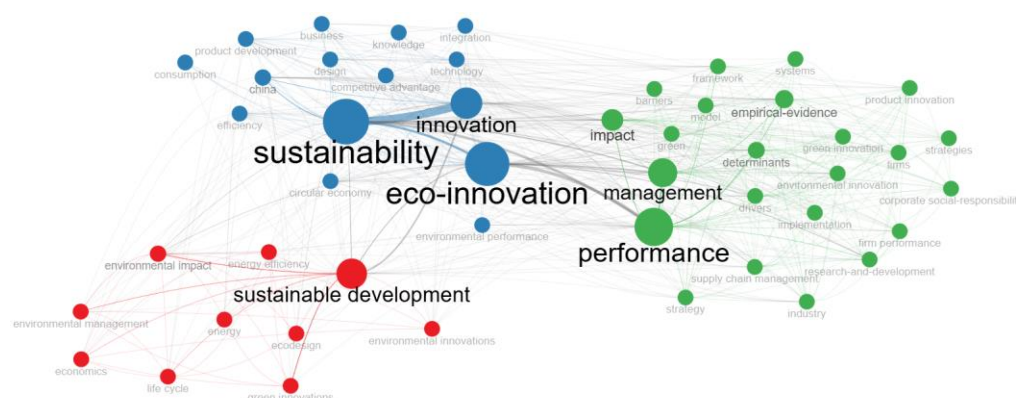

Figure 10: Keyword Plus Co-occurrence Network

The left section of the plot highlights the top journals contributing to the field. The Journal of Cleaner Production stands out as the most influential source, followed by Sustainability (Switzerland) and Resources Conservation and Recycling. As mentioned, these journals play a pivotal role in disseminating research on sustainability and eco-innovation, serving as essential platforms for advancing the field.

Moreover, the central section features the most prolific authors, such as SALA S, TSENG M, and BOCKEN N, showcasing their significant contributions. These authors consistently align their research with key topics, as illustrated in the right section of the plot, where frequently used keywords are displayed. Additionally, keywords such as sustainability, eco-innovation, and circular economy dominate the right section, underscoring their centrality in the literature, as shown in the previous section. The alignment between authors and keywords reflects the thematic focus of their work, emphasizing their impact on shaping the discourse around sustainable practices in engineering.

On the other hand, Figure 12 presents a thematic evolution analysis that illustrates the progression and transformation of key research themes across three distinct periods: 2001–2012, 2013–2018, and 2019–2024. This Sankey diagram visually captures how concepts evolve, merge, or diverge over time, highlighting the dynamic and evolving nature of the field. During the initial period (2001–2012), research focused on foundational themes such as eco-innovation, green innovation, environmental innovation, and sustainable innovation. These topics established the groundwork for exploring innovative practices to minimize environmental impact while fostering sustainability. Methodological frameworks, including life cycle assessment (LCA) and TRIZ (Theory of Inventive Problem Solving), gained prominence as tools for evaluating and implementing sustainable innovations. The thematic landscape expanded and diversified in the subsequent period (2013–2018), reflecting an increasingly applied and interdisciplinary focus. Eco-innovation and green innovation remained central while new topics such as environmental policy, governance, circular economy, and energy efficiency emerged. These themes emphasized the integration of sustainability into policymaking, industry practices, governance frameworks, and the development of energy-related solutions to promote sustainable practices. The most recent period (2019–2024) shows a thematic shift toward integrating sustainability into complex systems. Emerging themes, including sustainability, biomimicry, technological innovation, and barriers, highlight a deeper exploration of systemic and technological challenges in implementing sustainable practices. Established themes like eco-innovation and green innovation remain influential. At the same time, concepts such as environmental impact, China, and DEMATEL (Decision-Making Trial and Evaluation Laboratory) indicate a growing focus on regional applications and advanced analytical methodologies.

Finally, this analysis reveals a clear trajectory of growth, diversification, and increasing complexity within the field of eco-innovation and sustainability in engineering. The transition from foundational studies to more integrated and systemic approaches reflects the maturity of the field and its responsiveness to global challenges.

G. Thematic Map Analysis

The thematic maps provide a structured categorization of research themes based on two dimensions: Development Degree (Density) and Relevance Degree (Centrality). These visualizations enable the identification of themes' maturity and relevance within the research domain, segmented into four quadrants: Motor Themes, Basic Themes, Niche Themes, and Emerging or Declining Themes.

Figure 13 shows the thematic map derived from Author Keywords highlights several key trends. The Motor themes are highly developed and central, acting as driving forces in the research domain. Keywords such as green innovation, environmental sustainability, and corporate social responsibility dominate this quadrant, reflecting their strong interconnectivity and pivotal role in advancing sustainable engineering practices.

Additionally, foundational concepts such as sustainability, innovation, and sustainable development populate the Basic themes quadrant. These themes exhibit high centrality but lower density, indicating widespread relevance across research contexts without a deep specialization. The Niche themes show topics like economic growth and energy consumption are highly specialized but less central, signifying focused areas of research that, while important, exert limited influence on the broader research landscape.

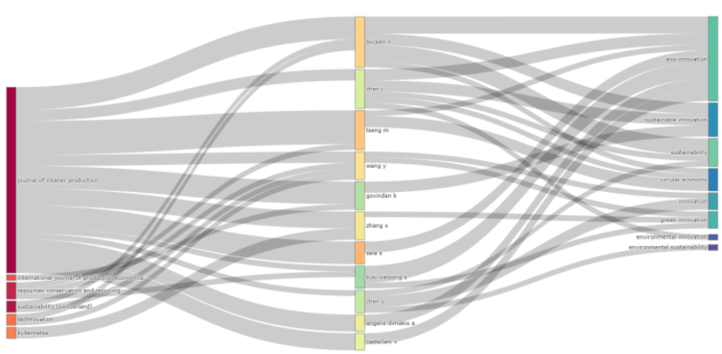

Figure 11: Three-Field Plot of Journals, Authors and Keywords

Finally, Emerging or Declining Themes include keywords such as eco-design and life cycle assessment. These themes occupy a quadrant that reflects areas either gaining traction or experiencing a decline in research activity. Their lower centrality and density highlight the need for further investigation to determine their potential for growth or reevaluation to assess their relevance within the academic community.

Figure 14 displays the Keywords Plus thematic map offers complementary insights into the field: Motor Themes: Dominant terms such as green innovations, environmental management, and life cycle highlight practical and policy-oriented aspects of sustainability. These themes play a critical role in shaping engineering solutions for environmental challenges. Basic Themes: Broad and widely applicable concepts like sustainability, eco-innovation, and performance appear here. These foundational themes support the theoretical framework of the field, serving as a springboard for more specialized studies. Niche Themes: This quadrant features specialized topics such as nanostructures and regulatory compliance. These terms cater to specific research interests but have limited interconnectivity with the core themes. Emerging or Declining Themes: Keywords like sustainable design and creativity are categorized here, signaling areas with potential for growth or those requiring revitalization through innovative methodologies.

IV. DISCUSSION

The results of this study corroborate trends identified in previous research, notably the work of Albareda and Hajikhani [39], who emphasized the exponential growth of literature on innovation for sustainability (IfS) over the past two decades. Consistent with these findings, our analysis reveals a marked increase in scientific production related to eco-innovation since 2010, particularly in countries such as China, the United Kingdom, and Italy. This trend suggests a direct correlation between implementing national sustainability policies and the rise in academic output.

Compared with the study by Fatma and Haleem [8], which examines the nexus between eco-innovation and sustainable development, our findings similarly underscore the increasing prominence of the circular economy and environmental management in recent scholarly discourse. Nevertheless, while Fatma and Haleem focus primarily on the influence of eco-innovation on the Sustainable Development Goals, our research concentrates on the intersections between engineering and eco-innovation, offering a complementary perspective.

Building upon this thematic evolution, the thematic map analysis (Figures 13 and 14), previously presented in the results section, reinforces the centrality of green innovation and corporate responsibility as motor themes. The latter confirms their pivotal role in current research and suggests a strong alignment with policy and industry-driven sustainability goals, which deserves deeper empirical validation in future work.

A notable distinction from prior studies is the identification of international collaboration networks, particularly between China and Southeast Asian countries. This dimension has not been extensively explored in previous reviews. This finding highlights the importance of fostering interdisciplinary and transnational collaborations as essential strategies for addressing global sustainability challenges.

V. CONCLUSIONS

The present review offers a comprehensive analysis of the research landscape on eco-innovation, environmental impact, and sustainability within engineering, uncovering significant trends, key contributions, and opportunities for future research. By examining 768 articles published between 2000 and 2024, the study highlights thematic developments, leading contributors, and influential sources that shape the field.

The findings reveal a substantial increase in scientific production, particularly from 2013 onward, with notable peaks in 2022 and 2023. This growth reflects heightened global awareness of sustainability challenges and the growing integration of eco-innovation into engineering practices. The consistent rise in original research articles underscores the field’s empirical focus and alignment with global policies promoting sustainable development.

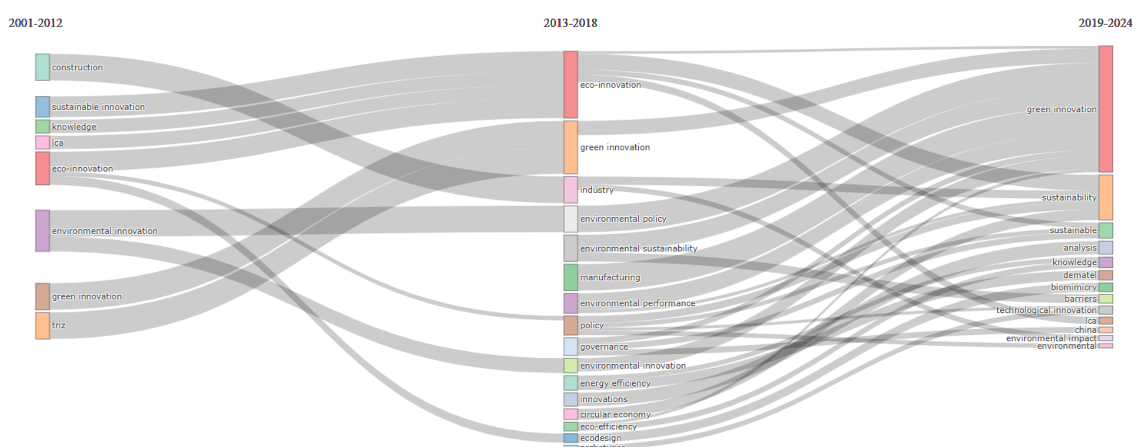

Figure 12: Thematic Evolution Analy

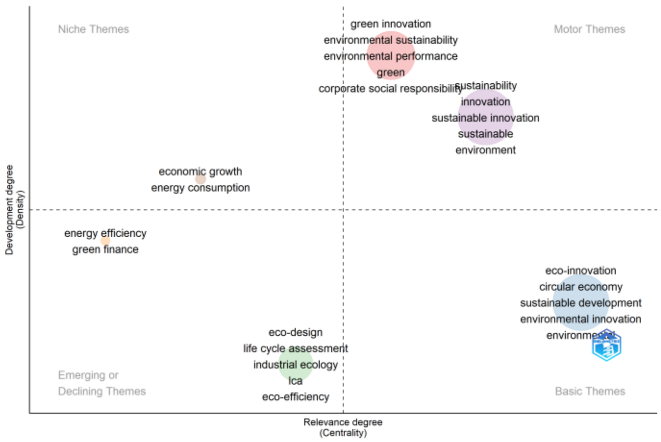

Figure 13: Thematic Map Based on Author Keywords

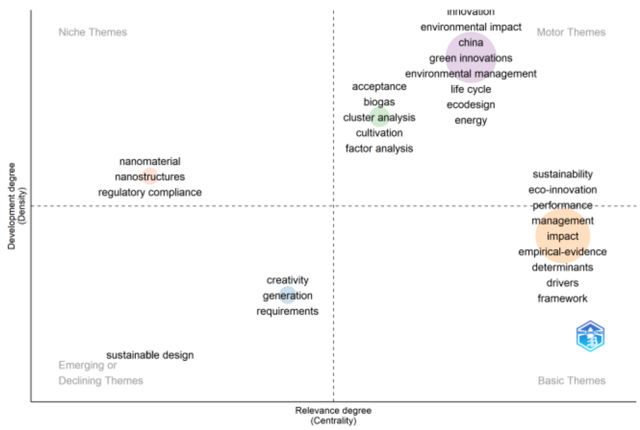

Figure 14: Thematic Map Based on Keywords Plus.

China, the United Kingdom, and Italy emerged as leading contributors in publication output and citations, demonstrating their central roles in advancing research on eco-innovation and sustainability. Institutions like Delft University of Technology and the University of Cambridge have significantly shaped the field through sustained research efforts. However, regional disparities, particularly in Latin America, highlight the need for increased investment and collaboration to address the underrepresentation of these regions in the global research landscape.

The thematic analysis reveals a dynamic and evolving research ecosystem. Core themes such as sustainability, eco-innovation, and green innovation form the foundational pillars of the field. Emerging topics, including eco-design and circular economy, indicate shifting priorities toward more integrated and systemic approaches in sustainable engineering. Keyword co-occurrence networks and thematic maps provide nuanced insights into the relationships between concepts, highlighting opportunities to deepen the integration of sustainability into policies and practices.

The Journal of Cleaner Production and Sustainability (Switzerland) stand out as the most influential sources, serving as critical platforms for disseminating research. Prolific authors such as SALA S and TSENG M have significantly shaped the research agenda, focusing on innovative approaches to address sustainability challenges. The alignment of these authors' contributions with key themes underscores their impact on advancing critical topics in the field.

Emerging and niche themes, such as nanostructures, eco-efficiency, and regulatory compliance, offer promising opportunities for further exploration, particularly in their application to engineering solutions. Addressing thematic gaps in underrepresented regions, alongside fostering interdisciplinary approaches, will be essential for advancing global collaboration and incorporating diverse perspectives into the research agenda.

This review highlights the central role of eco-innovation and sustainability within engineering research, offering valuable insights for academics, policymakers, and practitioners. By mapping thematic trends, identifying influential contributors, and exploring emerging areas, the study provides a structured roadmap to guide future investigations. It underscores the need for innovative and collaborative approaches to address urgent global sustainability challenges, laying the groundwork for impactful advancements.

In addition to outlining prevailing themes and leading contributors, the review uncovers critical gaps that warrant attention. Notably, underrepresenting institutions from the Global South reveals a structural imbalance in research capacity and access. Furthermore, the concentration of publications in a limited number of journals and countries raises concerns about potential citation and visibility biases. These observations highlight the urgency of fostering inclusive international collaboration, encouraging open-access dissemination, and investing in capacity-building efforts in underrepresented regions. Lastly, the lack of methodological convergence across studies indicates a pressing need to develop harmonized frameworks for consistently assessing eco-innovation impacts.

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