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Research Article

Mapping the Intersection of Artificial Intelligence and the Sustainable Development Goals: A Bibliometric and Scientometric Analysis (2003–2025)

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ABSTRACT

This study presents a comprehensive bibliometric analysis of global research at the intersection of Artificial Intelligence (AI) and the Sustainable Development Goals (SDGs) from 2023 to 2025, based on 1,349 Scopus-indexed documents. The findings reveal a rapidly emerging yet structurally diverse field characterized by high thematic dispersion, moderate growth, and early citation impact. India leads in research output, while countries like Malaysia and Saudi Arabia exhibit high international collaboration rates. Conceptual mapping identifies two dominant clusters: one focused on applied sustainability domains and another on foundational AI methods and education. Despite growing momentum, challenges remain in metadata consistency, ethical integration, and translation of knowledge into actionable outcomes. This work provides a critical reference point for advancing AI-SDG scholarship toward greater coherence, inclusivity, and global policy relevance.

1. INTRODUCTION

The convergence of Artificial Intelligence (AI) and the Sustainable Development Goals (SDGs) represents a transformative shift in the global research agenda, promising innovative solutions to some of the world's most pressing challenges. As AI technologies evolve, they offer unprecedented potential to accelerate progress toward achieving the 17 SDGs set forth by the United Nations, including areas such as poverty alleviation, quality education, climate action, and sustainable urban development. However, the integration of AI within the SDG framework remains a complex and multidisciplinary endeavor, requiring a nuanced understanding of how technological advancements align with policy, ethics, and social impact [1-3].

In recent years, the academic community has shown increasing interest in exploring the intersection of AI and sustainable development. This emerging research domain spans a wide array of disciplines, ranging from computer science and environmental studies to economics and public policy. Yet, despite the growing body of literature, there is a lack of consolidated knowledge about the structure, trends, and collaborative dynamics of this research landscape[4-6].

To address this gap, the present study conducts a comprehensive bibliometric analysis of global research linking AI and the SDGs. Using the Scopus database the largest abstract and citation database of peer-reviewed literature a total of 1,370 documents were retrieved using the search query "Sustainable Development Goals" AND "Artificial Intelligence" applied to article titles, abstracts, and keywords. The study period spans from 2023 to 2025, capturing the most recent contributions to this rapidly evolving field. Data analysis was carried out using RStudio and the Biblioshiny package, enabling the visualization and extraction of key bibliometric indicators [7].

The rest of the paper is organized as follows:

- Section 2 outlines the methodology, including search strategy, inclusion and exclusion criteria, and metadata quality.
- Section 3 presents the main information about the dataset, such as document distribution, citation patterns, and collaboration metrics.
- Section 4 identifies the most relevant publication sources, while

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- Section 5 examines the top contributing affiliations.
- Section 6 analyzes the corresponding authors' countries, with attention to international collaboration trends.
- Section 7 uses a WordCloud to visualize frequent keywords and thematic emphasis.
- Section 8 explores the co-occurrence network, revealing clusters of conceptual relationships and research directions.

This comprehensive approach aims to uncover structural patterns, key contributors, and emerging themes in AI research targeting sustainable development, thus offering a valuable roadmap for scholars, policymakers, and practitioners in this growing interdisciplinary field[8-10].

2. LITERATURE REVIEW

2.1 Theoretical Foundations and Early Contributions

The integration of Artificial Intelligence (AI) into the pursuit of the Sustainable Development Goals (SDGs) has garnered significant scholarly attention. Early studies have explored the multifaceted roles of AI in advancing specific SDGs, such as enhancing healthcare delivery (SDG 3), optimizing energy consumption (SDG 7), and supporting climate resilience (SDG 13). These investigations highlight AI's versatility and its potential to drive progress across diverse sectors[11-14].
Building upon this foundation, subsequent research has delved into the complex interplay between AI technologies and sustainable development initiatives. Scholars have examined how AI can both enable and hinder progress towards the SDGs, emphasizing the importance of ethical considerations and governance frameworks to ensure that AI applications align with sustainability objectives[15].

2.2 Bibliometric Analyses and Research Trends

Bibliometric analyses have been instrumental in mapping the evolving landscape of AI and SDG research. Studies employing bibliometric methods have revealed a significant increase in publications over recent years, indicating growing academic interest in this interdisciplinary field. Key research clusters identified include AI applications in energy efficiency, sustainable agriculture, and smart city development.
These analyses have also highlighted the predominance of research from developed countries, emphasizing the need for greater inclusion of perspectives from the Global South. This aligns with concerns about the digital divide and the equitable distribution of AI benefits [16,17].

2.3 AI Applications in Specific SDGs

AI's application across various SDGs has been extensively documented. In the realm of healthcare (SDG 3), AI has been leveraged for disease prediction, personalized medicine, and efficient resource allocation. For instance, machine learning algorithms have been developed to predict disease outbreaks and optimize treatment plans, thereby improving health outcomes.
In the context of sustainable cities (SDG 11), AI technologies have facilitated smart urban planning, traffic management, and waste reduction. Predictive analytics and real-time data processing have enabled cities to enhance operational efficiency and reduce environmental footprints.
Regarding climate action (SDG 13), AI has been employed to model climate scenarios, monitor environmental changes, and support disaster response strategies. These applications demonstrate AI's potential to contribute significantly to climate resilience and adaptation efforts [18,19].

2.4 Ethical Considerations and Challenges

Despite the promising applications of AI in advancing the SDGs, ethical concerns persist. Issues such as data privacy, algorithmic bias, and the potential for exacerbating social inequalities have been raised. Scholars have cautioned that without careful governance, AI could inadvertently hinder progress on certain SDGs, particularly those related to equity and justice.
Furthermore, the environmental impact of AI technologies, including high energy consumption and electronic waste, poses challenges to sustainability. Researchers advocate for the development of green AI practices and policies that align technological advancement with environmental stewardship [20,21].

2.5 Future Directions and Research Gaps

The literature indicates a need for more inclusive and context-specific research on AI and the SDGs. There is a call for studies that incorporate diverse cultural, economic, and geographic perspectives to ensure that AI solutions are equitable and effective globally. Additionally, interdisciplinary collaborations between technologists, policymakers, and social scientists are essential to address the complex challenges at the intersection of AI and sustainable development.
In conclusion, while AI holds significant promise for advancing the SDGs, realizing this potential requires addressing ethical concerns, promoting inclusive research practices, and fostering cross-sectoral collaborations. Continued

bibliometric analyses and empirical studies will be vital in guiding the responsible integration of AI into sustainable development efforts [22-25]

3. METHODOLOGY

This study employed a structured bibliometric analysis approach to investigate the global research trends linking *Artificial Intelligence (AI)* with the *Sustainable Development Goals (SDGs)*. The methodology consisted of a clearly defined search strategy, inclusion and exclusion criteria, and systematic data analysis using RStudio and the Biblioshiny package [26].

3.1 Search Strategy

The bibliographic data were retrieved from the Scopus database, which was selected due to its extensive and multidisciplinary coverage of peer-reviewed scientific literature. Scopus is widely regarded as a reliable source for bibliometric research due to its high indexing standards, broad international scope, and detailed metadata fields. A total of 1,370 documents were retrieved using the advanced search query: "Sustainable Development Goals" AND "Artificial intelligence"
(Search fields: Article Title, Abstract, and Keywords)
This query was specifically designed to capture scholarly works that explicitly link AI with the SDGs, focusing only on works that mention both concepts in core metadata fields to ensure thematic relevance.

3.2 Inclusion and Exclusion Criteria

To maintain the focus and relevance of the analysis, the following criteria were applied:

- **Inclusion Criteria**:
  - Articles published between 2023 and 2025, ensuring a contemporary overview of emerging trends.
  - Publications in any language (Scopus metadata indicated no missing values in the Language field).
  - All document types indexed in Scopus, including research articles, conference papers, and reviews.
  - Availability of complete metadata in core fields (Title, Authors, Abstract, Journal Source, and Publication Year).
- **Exclusion Criteria:**
  - Documents with entirely missing critical metadata such as Title, Authors, or Journal Name (although none were found missing in these fields).
  - Studies not relevant to the dual theme of AI and SDGs upon closer inspection during data curation.
  - Duplicate records or improperly indexed entries.

3.3 Study Selection

The dataset initially consisted of 1,370 records exported from Scopus. These were subsequently processed using the Biblioshiny interface of the bibliometrix package in RStudio (R language environment). After loading into Biblioshiny, the dataset yielded 1,349 valid documents, with minor discrepancies due to metadata parsing issues or exclusion of incomplete records.
Metadata quality was assessed, and although core fields (Document Type, Journal, Title, Year, Citations, and Language) were fully intact, some fields had partial or significant data omissions.(see Table I)

TABLE .I. SUMMARIZES THE METADATA COMPLETENESS:

Metadata Field	Missing Count	Missing %	Quality
Abstract	19	1.41%	Good
Author	21	1.56%	Good
Affiliation	30	2.22%	Good
DOI	62	4.60%	Good
Keywords (DE)	199	14.75%	Acceptable
Corresponding Author	353	26.17%	Poor
Keywords Plus (ID)	553	40.99%	Poor
Cited References (CR)	1349	100.00%	Completely Missing
Science Categories	1349	100.00%	Completely Missing

4. MAIN INFORMATION ON THE BIBLIOGRAPHIC DATASET

The bibliometric dataset analyzed in this study spans the years 2023 to 2025, reflecting a contemporary and focused snapshot of global scholarly output at the intersection of Artificial Intelligence (AI) and the Sustainable Development Goals (SDGs). A total of 1,349 documents were extracted from 824 distinct sources, including journals, books, and conference proceedings. The annual growth rate of publications within this time frame is modest, at 3.34%, indicating a steady but not explosive rise in research output.

The average age of the documents stands at 0.984 years, which underscores the recency of the works, further confirming that the research area is emergent and developing. Despite their young age, the documents exhibit a healthy average citation rate of 5.047 per document, suggesting early academic engagement and relevance within the scientific community.

As illustrated in Figure 1, the dataset is characterized by a high degree of diversity in document types. Peer-reviewed articles constitute the largest share (534 documents), followed by book chapters (242) and conference papers (296). The presence of 168 reviews further highlights the field's growing maturity and the consolidation of existing knowledge. Interestingly, a few entries are hybrids, such as "article article" or "book chapter conference paper", reflecting inconsistencies in metadata classification likely stemming from Scopus export anomalies discussed earlier.

The content analysis of the documents shows a strong emphasis on keyword usage. There are 6,422 'Keywords Plus' (automatically generated from Scopus) and 3,746 author-defined keywords, which points to a rich and varied thematic landscape. This also correlates with the interdisciplinary nature of the topic, where different researchers may frame similar concepts using diverse terminologies.

From the perspective of authorship and collaboration, the dataset includes 4,785 unique authors, with 159 documents written by a single author and 190 single-authored documents in total. The average number of co-authors per document is 3.86, indicating a moderate level of collaborative effort. Moreover, 35.73% of all publications involved international collaboration, which aligns well with the global nature of the SDGs and the transdisciplinary scope of AI research.

Collectively, these statistics highlight a growing, internationally engaged, and diverse research ecosystem focused on AI applications for sustainable development. The breadth of source types, the variety of keywords, and the wide authorship base reflect the complexity and inclusiveness of the domain, even at this relatively early stage of bibliographic maturity.

Fig. 1. Document Types and Distribution in AI-SDG Research (2023–2025)

5. MOST RELEVANT SOURCES

The analysis of the most prolific publication sources reveals a concentrated yet diverse set of platforms actively contributing to the intersection of Artificial Intelligence and the Sustainable Development Goals. As shown in Figure 2, *Sustainability (Switzerland)* leads significantly, with 55 publications, making it the dominant outlet for research in this area. This journal's open-access model, coupled with its wide thematic scope on sustainability issues, likely contributes to its high volume of relevant publications.

Trailing behind are several conference proceedings and specialized book series. The *Lecture Notes in Networks and Systems* contributes 22 publications, reflecting the technical and systems-oriented nature of much of the AI-related SDG research. Similarly, the *Philosophical Studies Series* with 18 entries presents an interesting contrast, suggesting that philosophical and ethical dimensions of AI for sustainable development are also being actively explored indicating a cross-disciplinary spread.

The *Communications in Computer and Information Science* (CCIS) series, with 17 publications, and *Discover Sustainability* and *Sustainable Development*, both with 13 papers, showcase a balance between computing-focused and sustainability-focused venues. Their presence in the top tier underlines how applied computer science is being increasingly framed within broader developmental contexts.

Further supporting this trend, the *Lecture Notes on Data Engineering and Communications Technologies* with 12 contributions and *IEEE Access* with 10 papers reflect ongoing efforts in technical innovation, data-driven methods, and open-science dissemination. Meanwhile, the inclusion of *CEUR Workshop Proceedings* (9 publications) signifies the role of preliminary and emerging research often presented in workshops and symposia before journal publication.

Lastly, the specialized source *Machine and Deep Learning Solutions for Achieving the Sustainable Development Goals* also appears with 9 entries, highlighting the growing interest in thematic compilations dedicated entirely to AI applications in sustainability.

Collectively, these sources demonstrate a multifaceted publishing ecosystem where open-access journals, conference proceedings, and interdisciplinary book series converge. This diversity reflects the thematic richness and methodological plurality of the field, encompassing everything from engineering and data science to ethical theory and policy-oriented discussions.

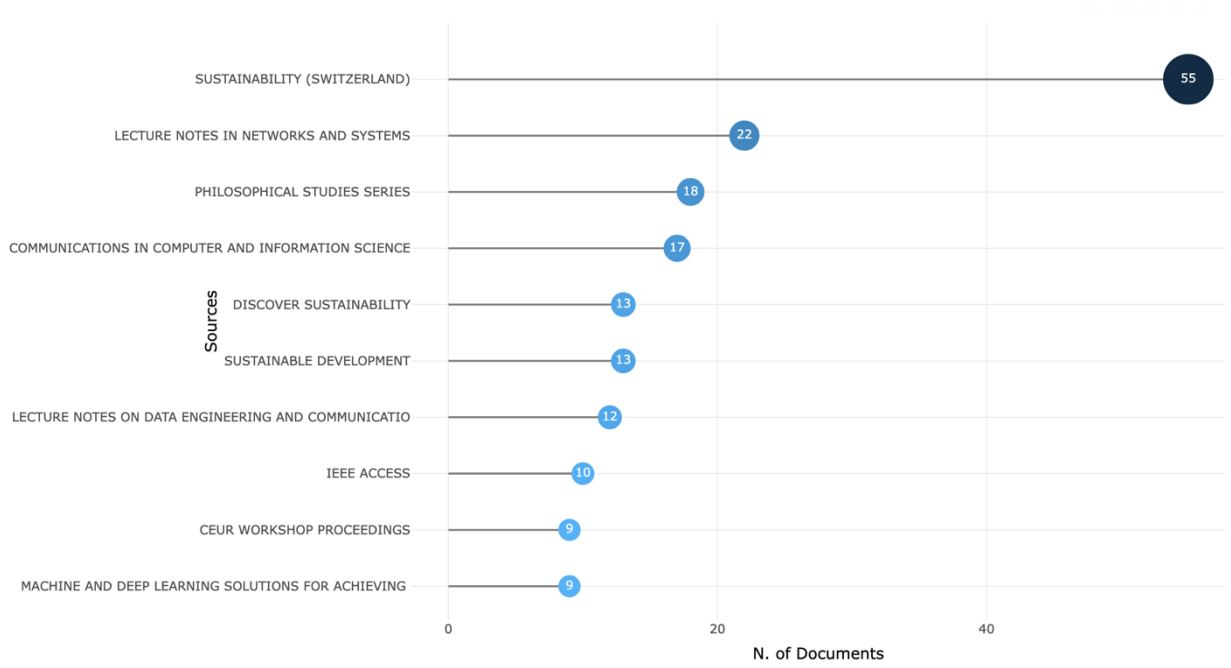

Fig. 2. Top 10 Most Relevant Sources Publishing on AI and SDGs

6. MOST RELEVANT AFFILIATIONS

The analysis of the most productive affiliations in the field of Artificial Intelligence applied to the Sustainable Development Goals reveals a globally distributed network of institutions, with notable activity in Asia, the Middle East, and Europe. As illustrated in Figure 3, Uttaranchal University emerges as the top contributing institution, with 28 publications, indicating a significant institutional focus on sustainability-driven AI research. This strong showing may reflect strategic research priorities or internal funding mechanisms aimed at aligning with the SDG agenda.

Closely following is the University of Johannesburg with 26 publications, reinforcing Africa's increasing visibility in global sustainability research. The university's contributions may represent a regional push to integrate AI solutions into developmental challenges facing the Global South, especially within the context of inequality, resource management, and public infrastructure.

The University of Delhi, a prominent Indian institution, ranks third with 17 publications, aligning with India's broader academic engagement in AI and sustainable development. Its output correlates with that of Amrita School of Business (16 publications) and Chitkara University Institute of Engineering and Technology (15 publications), together reflecting a strong cluster of Indian institutions investing in applied research at the AI–SDG nexus.

Qatar University, KTH Royal Institute of Technology in Sweden, and King Fahd University of Petroleum and Minerals in Saudi Arabia each contributing 15 or 14 publications highlight the diverse geographical representation in this field. These affiliations suggest that both oil-rich economies and technologically advanced nations are actively investigating the role of AI in transitioning toward more sustainable practices.

Amity University and the National University of Singapore, each contributing 13 publications, round out the top ten, with the latter representing a highly research-intensive environment known for its AI initiatives. Singapore's presence further affirms the growing prominence of Southeast Asia in the AI-for-Good research landscape.

Together, these affiliations represent a rich tapestry of institutional leadership across different regions. The concentration of outputs among Indian institutions reflects both capacity and strategic orientation, while the inclusion of African, Middle Eastern, and European universities illustrates a global commitment to leveraging AI in support of the SDGs. This distributed authorship landscape also complements the previously noted 35.73% international co-authorship rate, reinforcing the collaborative and transnational character of this emerging research field.

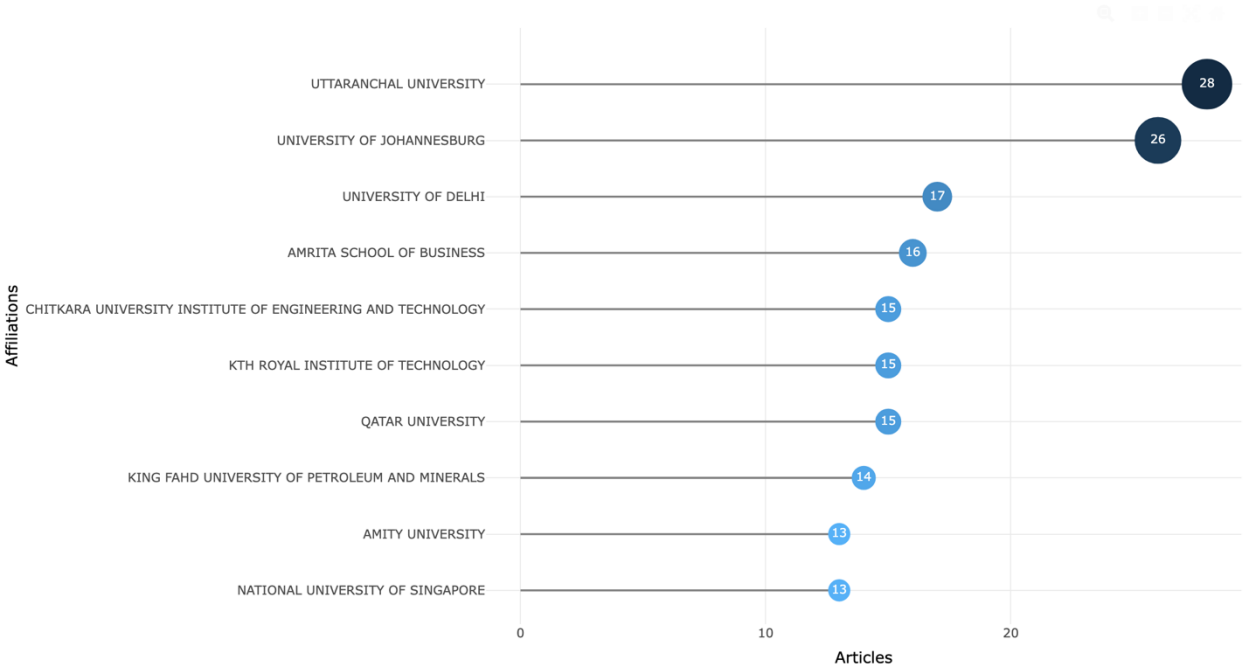

Fig .3. Most Productive Affiliations in AI-SDG Literature

7. CORRESPONDING AUTHOR'S COUNTRIES

The distribution of corresponding authors by country, as depicted in Figure 4, highlights a globally diverse research landscape in the domain of Artificial Intelligence and the Sustainable Development Goals. India leads with 188 articles, accounting for 13.9% of the total contributions. Notably, 135 of these are single-country publications (SCP), while 53 are multi-country publications (MCP), yielding a 28.2% MCP rate. This demonstrates India's dominant presence in domestic research output, while still engaging in a substantial number of international collaborations.

China follows as the second-highest contributor with 101 articles (7.5%), featuring 63 SCPs and 38 MCPs, resulting in a 37.6% international collaboration rate. This balance indicates that China maintains a strong internal research base while actively partnering with other countries, surpassing India in proportion of internationally co-authored work.

Spain, Italy, and the USA display similar volume levels 38, 34, and 33 articles respectively but differ in their collaboration dynamics. The USA stands out with a 45.5% MCP rate, reflecting a strong inclination toward international partnerships. Likewise, Italy and Spain both show healthy MCP rates of 32.4% and 31.6%, respectively, suggesting that European institutions are actively engaged in cross-border scientific networks.

Malaysia and Saudi Arabia, though contributing fewer papers (30 and 27 articles, respectively), exhibit remarkably high MCP percentages 63.3% and 70.4%. These figures signal that researchers in these countries are deeply embedded in global research collaborations, likely leveraging international partnerships to enhance local research capabilities and visibility.

The United Kingdom and Australia also demonstrate high collaboration tendencies. The UK has an equal split between SCP and MCP (15 each), reflecting a 50% international collaboration rate, while Australia surpasses that with 54.5% MCP, indicating that over half of its corresponding author contributions are internationally co-authored.

On the other hand, South Africa, with 25 articles and only 5 MCPs (20%), appears more nationally focused in its contributions. This contrasts with other countries at similar output levels but may reflect localized research priorities or limitations in international funding networks.

Overall, this distribution illustrates both the dominance of certain countries in absolute output especially India and China and the central role of international collaboration in shaping the field. High MCP rates in countries like Saudi Arabia, Malaysia, and Australia underscore the collaborative ethos underpinning AI for sustainable development, reinforcing its inherently global and interdisciplinary character.

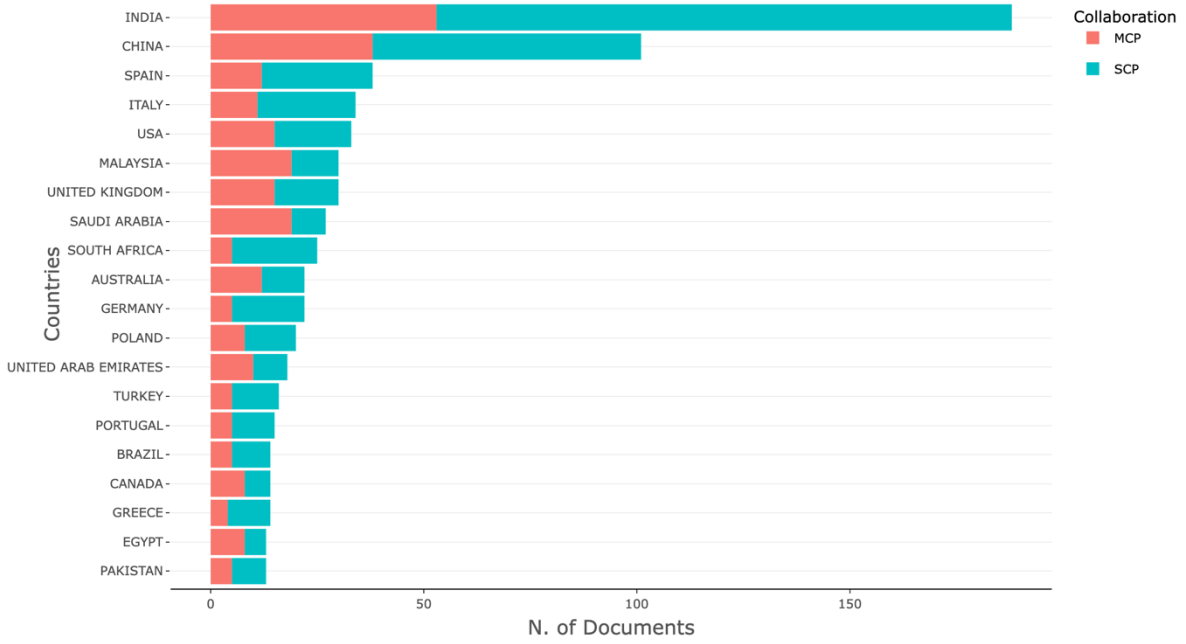

Fig .4. Corresponding Authors' Countries and International Collaboration

8. WORDCLOUD ANALYSIS

The WordCloud visualization, as illustrated in Figure 5, offers a thematic snapshot of the most frequently occurring terms in the analyzed dataset. At the core of the research landscape is the term "artificial intelligence", which dominates with a frequency of 490, affirming its central role in the literature. This is closely followed by "sustainable development goal" (339 occurrences) and "sustainable development" (306 occurrences), highlighting the dual thematic focus of the dataset and confirming the alignment of AI technologies with global sustainability agendas.

Interestingly, both singular and plural forms of the term "sustainable development goal" and "sustainable development goals" appear separately with substantial frequencies (339 and 198, respectively), indicating variations in author keyword usage and suggesting a need for standardization in keyword practices for improved discoverability. When considered together, they significantly amplify the visibility of SDG-related content.

The prominence of "machine learning" (140) and its hyphenated variant "machine-learning" (96) further reflects the methodological backbone of many studies in the corpus. This dual listing implies inconsistency in keyword formatting but also shows the widespread application of machine learning techniques in sustainability contexts.

Other frequently used terms such as "human" (98) and "united nations" (91) point to the human-centric and policy-oriented focus of the research. The presence of the term "United Nations" specifically underlines the institutional framework within which many of the sustainable development discussions are situated, reinforcing the connection to the official SDG framework established by the UN.

Keywords like "sustainability" (79) and "climate change" (73) indicate that environmental dimensions remain a dominant concern within the AI-for-Good literature. Their high frequency suggests that research is not only aligned with broad sustainability goals but also addresses more specific challenges such as climate action.

Overall, the WordCloud analysis demonstrates a strong convergence between cutting-edge technologies like artificial intelligence and machine learning, and pressing global challenges encapsulated by the SDGs. The interplay between technological keywords and sustainability-related terms highlights the multidisciplinary and application-driven nature of the field.

Fig .5. WordCloud of Most Frequent Keywords

9. CO-OCCURRENCE NETWORK ANALYSIS

The co-occurrence network, visualized in Figure 6, offers a map of conceptual relationships among key research terms, revealing how frequently and closely different themes appear together across the literature. Each node in the network represents a keyword, and its size and position reflect its centrality and importance in connecting research themes much like intersections in a city road map where some hubs are major roundabouts and others are side streets.

Two primary clusters emerged from the analysis. Cluster 2, the most dominant, includes terms like “sustainable development goals”, “machine-learning”, and “deep learning”. Among them, “sustainable development goals” holds the highest betweenness centrality (37.509), acting as a key bridge connecting various research themes. In a metaphorical sense, it functions like a central train station, linking different lines AI, policy, energy, and urban studies making it a critical transit point in the intellectual landscape.

“Machine-learning” also plays a pivotal role, with high closeness and PageRank scores (0.018 and 0.035, respectively), signifying not just its frequency but its strategic position at the heart of the network. It serves as a reliable expressway, directly connecting to numerous other keywords such as “deep learning”, “energy”, and “sustainable city”. This reflects the foundational role of machine learning methods in driving innovations across sustainable applications.

On the fringes but still important within Cluster 2 are “circular economy”, “energy”, and “sustainable city”, each having modest yet meaningful centrality scores. They represent emerging routes in the map less traveled than the main highways but increasingly significant as the field evolves toward practical, domain-specific implementations of AI for sustainability.

In contrast, Cluster 1 presents a more technical and educational subgroup. It includes terms like “adversarial machine learning”, “contrastive learning”, “students”, and “case-studies”. While these nodes have lower PageRank and betweenness values, they reflect a more focused exploration of machine learning pedagogy and robustness. For example, “contrastive learning” and “adversarial machine learning” share nearly identical closeness and betweenness, suggesting that they are conceptually intertwined, often co-occurring in literature dealing with advanced AI techniques or vulnerabilities.

“Students” and “case-studies” imply a practical or educational orientation, suggesting that Cluster 1 might be akin to a university campus less central to the transportation network but vital for knowledge cultivation and training.

Together, these clusters outline the dual nature of current research: one stream focused on high-impact, policy-aligned outcomes (Cluster 2), and another grounded in technical innovation and education (Cluster 1). Their interconnections reflect the growing maturity and multidimensionality of AI research aligned with sustainable development goals.

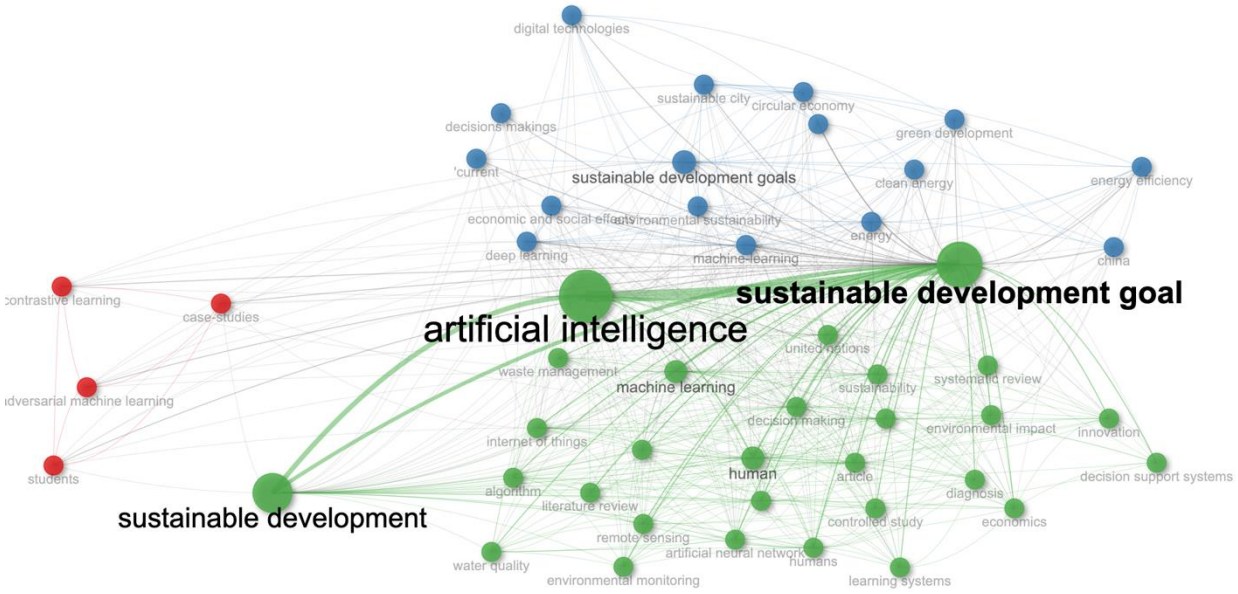

Fig .6. Keyword Co-occurrence Network

10. DISCUSSION

The intersection of Artificial Intelligence (AI) and the Sustainable Development Goals (SDGs) has evolved into a vibrant interdisciplinary research domain, as evidenced by the bibliometric data extracted from Scopus covering the years 2023 to 2025. This discussion offers an integrative interpretation of the empirical findings, advancing beyond mere reporting to articulate the structural, thematic, and geographical dynamics of the field and situating them within broader scholarly and policy contexts. The analysis foregrounds the emergent character of AI-SDG scholarship while revealing critical gaps and tensions that must be addressed for the field to mature in scope, coherence, and global relevance.

10. 1A Youthful Field with Rapid Uptake

The temporal profile of the dataset characterized by an average document age of less than one year and a moderate annual growth rate signals a field in its formative stage. Despite the recency of contributions, the average citation rate exceeding five citations per document reflects early scholarly traction. Such citation density, typically associated with more established domains, suggests that AI-SDG research is not only timely but also rapidly acquiring intellectual legitimacy.

This dynamic is reinforced by the wide diversity of document types. Journal articles dominate the dataset, yet the high volume of book chapters and conference proceedings underscores the provisional and exploratory nature of much of the discourse. The presence of 168 review articles further affirms that the community is actively engaged in knowledge consolidation, aiming to anchor this interdisciplinary inquiry within a more stable theoretical and methodological scaffold.

10. 2Structural Pluralism and Knowledge Dispersion

The dispersion of publications across 824 unique sources reflects structural pluralism and thematic richness. *Sustainability (Switzerland)*, by far the most prolific source, exemplifies the dominant role of open-access, generalist sustainability journals in shaping the discourse. Meanwhile, the inclusion of highly specialized series such as *Lecture Notes in Networks and Systems* and *Philosophical Studies Series* reveals the intellectual breadth of the field spanning technical, philosophical, and applied dimensions.

This multiplicity of publication venues is mirrored in the diverse keyword landscape. The dataset features more than 10,000 combined Keywords Plus and author-defined keywords, indicating a lack of terminological standardization. The coexistence of variants such as “machine learning” and “machine-learning” or “sustainable development goal” and “sustainable development goals” points to a structural dissonance that may inhibit metadata harmonization and literature discoverability. The field would benefit from a concerted effort to unify taxonomies, enhancing semantic interoperability and cross-disciplinary citation visibility.

10. 3Global Distribution and Epistemic Shifts

A key contribution of this study lies in its unpacking of the global geography of knowledge production. India emerges as the most prolific country, followed by China, Spain, Italy, and the USA. This distribution contrasts with traditional science geographies, marking a shift in epistemic authority. Indian institutions not only lead in output but also dominate among the most productive affiliations. This rise aligns with broader national strategies promoting AI innovation for development.

Interestingly, countries with smaller outputs such as Saudi Arabia, Malaysia, and Australia demonstrate higher multi-country publication (MCP) rates. These nations are leveraging international collaborations to position themselves within the global knowledge system, often compensating for smaller domestic ecosystems. The high MCP rates suggest a dual imperative: building internal research capacity while embedding within transnational scientific networks. Conversely, countries like India and South Africa exhibit lower MCP rates, implying stronger internal capacities or nationally focused research agendas.

10. 4Thematic Landscapes: From Application to Infrastructure

The Word Cloud and co-occurrence network analyses provide a window into the thematic architectures shaping the discourse. Central terms such as "artificial intelligence," "sustainable development goals," and "machine learning" dominate, establishing the field's epistemic anchors. Yet, the co-occurrence network reveals deeper structure: two primary thematic clusters demarcating distinct epistemological orientations.

Cluster 2, the more influential, is anchored around applied sustainability themes—"sustainable city," "energy," "circular economy," and "climate change." These terms exhibit high centrality metrics, suggesting that much of the literature is outcome-oriented, aimed at deploying AI tools to address specific SDG challenges. The pervasiveness of terms like "deep learning" within this cluster indicates a strong methodological consistency grounded in data-intensive AI approaches.

Cluster 1, by contrast, is more inward-looking and methodological, containing terms such as "adversarial machine learning," "contrastive learning," "students," and "case studies." This cluster maps onto a pedagogical and theoretical core, reflecting research on algorithmic robustness, AI education, and instructional design. The coexistence of these clusters illustrates the field's bifocal nature: simultaneously building theoretical infrastructure and pursuing applied impact.

10. 5Alignments and Tensions Between Structure and Function

Comparing these thematic clusters with institutional and geographic data reveals structural tensions. For instance, institutions and countries with high publication counts but low MCP rates appear more aligned with Cluster 1 themes suggesting a domestic emphasis on capacity building and foundational research. Meanwhile, actors with higher collaboration rates are more engaged with Cluster 2 themes, often tackling global challenges through joint research agendas. This pattern indicates that transnational collaboration may be a proxy for problem-oriented research, while nationally concentrated outputs reflect investments in disciplinary infrastructure.

Another tension emerges from the disparity between the conceptual focus of the literature and the nature of the publication formats. Despite strong thematic emphasis on practical, policy-relevant issues (e.g., climate change, smart cities), a considerable portion of the dataset consists of book chapters and conference proceedings. These formats, though valuable for disseminating preliminary work, may lack the empirical rigor or policy traction needed to influence decision-making at scale. The field may benefit from increased representation in high-impact, peer-reviewed journals to translate ideas into actionable evidence.

Moreover, ethical and institutional considerations though present in the WordCloud through terms like "human" and "United Nations" are relatively marginal in the co-occurrence network. This marginality may reflect either the novelty of ethical debates in AI-SDG literature or a lack of integration with technical and applied domains. Addressing this gap is crucial. As AI interventions scale within development contexts, the normative frameworks guiding their deployment must be as robust as the algorithms themselves.

10. 6Toward a Future Research Agenda

This discussion yields several implications for the future trajectory of AI-SDG scholarship. First, greater emphasis must be placed on harmonizing metadata and terminologies. The observed inconsistency in keyword formatting and concept labeling hinders the traceability and synthesis of knowledge across platforms and disciplines.

Second, the field should embrace a more intentional integration of ethical, legal, and social implications (ELSI) into mainstream research. As the volume of technical literature grows, questions of accountability, transparency, and justice must not remain peripheral. Journals, funding bodies, and institutional ethics boards can play catalytic roles in mainstreaming ELSI considerations.

Third, enhancing methodological rigor particularly in conference and chapter contributions will be essential. Given the applied ambitions of much of the literature, ensuring reproducibility, validation, and real-world applicability must become central evaluation criteria. This shift will also help bridge the gap between academic outputs and policy uptake.

Fourth, cross-regional collaborations should be incentivized, particularly those that bridge Global North and Global South actors. Such partnerships can mitigate knowledge asymmetries, diversify epistemic perspectives, and co-produce context-sensitive AI applications that resonate with local sustainability needs.

Finally, the bifocal structure of the field application versus infrastructure should not be seen as a dichotomy but as a symbiosis. Technical and theoretical advancements are foundational to scaling impactful AI solutions, while real-world challenges provide fertile ground for refining methodologies and exposing blind spots.

AI for SDGs represents a research frontier defined by promise, complexity, and urgency. The bibliometric patterns identified in this study reveal a rapidly expanding, globally distributed, and thematically diverse field that is still in search

of structural coherence and ethical grounding. As the field matures, the challenge will be to integrate its heterogeneous parts into a cohesive whole one that balances innovation with responsibility, global goals with local realities, and disciplinary excellence with systemic change. Only then can the full potential of AI be realized in service of sustainable development.

11. CONCLUSION

This study provides the first comprehensive bibliometric mapping of scholarly activity at the intersection of Artificial Intelligence (AI) and the Sustainable Development Goals (SDGs) within the critical window of 2023–2025. Through a methodologically rigorous analysis of 1,349 Scopus-indexed documents, it reveals a rapidly emerging research landscape that is intellectually expansive, geographically dispersed, and thematically multifaceted.

The findings underscore that AI-SDG scholarship is still in its formative phase, yet already marked by robust citation engagement, diverse document types, and dynamic keyword usage. This evidences both the enthusiasm of the research community and the urgency of the societal problems it seeks to address. The dual thematic clusters uncovered—spanning applied sustainability interventions and foundational technical methodologies illustrate a field striving to bridge practical utility with conceptual refinement.

Institutional and national participation patterns reveal a decentralizing geography of innovation. Countries such as India and South Africa are demonstrating strong autonomous output, while others, notably Malaysia, Saudi Arabia, and Australia, are engaging through intensive international collaborations. This diversification of knowledge production is essential for embedding contextual relevance and global equity into AI-driven sustainable development solutions.

However, several structural and epistemic challenges remain. Terminological inconsistency, limited integration of ethical considerations, and the predominance of exploratory formats over policy-facing outputs hinder the translation of research into systemic impact. Addressing these limitations requires harmonization of metadata practices, greater methodological rigor, and a re-centering of ethical, legal, and social dimensions within mainstream technical research.

Ultimately, AI for the SDGs is not merely a technological endeavor it is a socio-technical paradigm shift. As the field moves forward, its success will depend not only on algorithmic sophistication but also on its ability to foster inclusive governance, cross-regional collaboration, and shared epistemologies. By understanding where the field currently stands its strengths, gaps, and trajectories this study provides a critical foundation for shaping its future evolution.

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