EXPLORING GLOBAL TRENDS IN AI-DRIVEN ESG: RESEARCH FOR ADVANCING SUSTAINABLE FINANCE

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Abstract: This study explores the global scientific landscape of Artificial Intelligence (AI) applications in Environmental, Social, and Governance (ESG) research, focusing on implications for sustainable finance. Using bibliometric network analysis of 581 peer-reviewed publications from 2005 to 2025, retrieved from Scopus and Web of Science, the paper identifies key publication trends, leading countries and institutions, and thematic research clusters. The findings reveal rapid growth in AI-driven ESG literature since 2015, with strong contributions from India, the United States, and the United Kingdom. Co-authorship and citation analyses highlight hubs of collaboration and influence within the global research community. Cluster mapping identifies four main research fronts: ESG accountability through advanced technologies, AI-driven climate risk management, digital transformation in ESG practices, and AI-based decision-making for sustainability. By uncovering the structure and trajectory of this emerging domain, the study offers insights into how AI-enhanced ESG research supports improved decision-making, accountability, and innovation in sustainable finance.

Keywords: Artificial Intelligence, ESG, Sustainable Finance, Sustainability, Bibliometric Analysis

INTRODUCTION

Artificial Intelligence (AI) is rapidly reshaping the financial landscape, particularly in the realm of Environmental, Social, and Governance (ESG) practices. From streamlining sustainability reporting to enhancing risk assessment and investment transparency, AI-driven tools are increasingly central to how institutions respond to ESG challenges (Božić, 2023; Di Vaio et al., 2020; Goralski & Tan, 2020). As global finance confronts rising demands for ethical finance, accountability and data-driven decision-making, the intersection of AI and ESG is emerging as a crucial area of both academic and practical interest.

A growing body of literature explores the role of AI technologies, such as machine learning and natural language processing, in enabling both operational efficiency and sustainability integration (Ionescu, 2025; Kim et al., 2020). However, research also underscores persistent concerns, including algorithmic bias, data opacity, and regulatory ambiguity, which may undermine ESG goals if not critically addressed (Boppiniti, 2023; Oladoyinbo et al., 2024).

While studies demonstrate AI's capacity to support climate resilience, corporate governance, and responsible investment practices (Gomes & Karim, 2024; Kalusivalingam et al., 2022; Vashishth et al., 2024), the academic field remains fragmented. Variability in case studies, methodological designs, and reporting standards limits comprehensive understanding and comparability. Furthermore, despite the rapid expansion of AI-ESG literature, few efforts have been made to systematically map its intellectual structure, collaborative networks, or thematic evolution.

This study addresses this gap by conducting a bibliometric analysis of AI-driven ESG research. Based on 581 peer-reviewed publications from Scopus and Web of Science, it identifies leading contributors, citation influence, and thematic research clusters that define the field's current trajectory. The aim is to support finance researchers and practitioners in navigating emerging ESG technology.

The paper begins by outlining the methodological approach, including data collection from Scopus and Web of Science and the application of VOSviewer for bibliometric network analysis. The results section examines trends in publication output, identifies leading contributing countries and journals, and presents a thematic cluster analysis. The study concludes with a discussion of the main implications, acknowledges key limitations, and proposes directions for future research in AI-driven ESG analysis.

Methodology

This study employs a bibliometric analysis approach, which is well-suited to mapping the structure, development, and thematic evolution of research fields (Donthu et al., 2021; Ellegaard, 2018). This methodology enables the identification of publication trends, geographical contributions, scholarly influence, keyword dynamics, and thematic clusters.

Research Methodology

The analysis is structured around five key dimensions:

1. Temporal distribution of publications;
2. Geographical distribution of scholarly contributions;
3. Citation and journal impact analysis;
4. Keyword co-occurrence and evolution;
5. Thematic clustering of AI-driven ESG research areas.

This multidimensional design ensures depth in the exploration of the field. Temporal trends help trace the evolution of interest over time; geographical distribution reveals disparities in global participation; citation analysis highlights influential sources; keyword mapping detects core topics and shifts in discourse; and clustering identifies dominant themes and future research avenues.

Data Sources and Search Strategy

The data was extracted from two major bibliographic databases: Scopus and Web of Science (WoS). These sources were selected for their extensive coverage of peer-reviewed literature and their suitability for bibliometric research. The search strategy was carefully crafted to capture publications focusing on AI applications in ESG and sustainability domains. The query included terms such as:

("Artificial Intelligence" OR "AI" OR "Machine Learning" OR "Deep Learning" OR "Neural Networks" OR "Natural Language Processing" OR "Reinforcement Learning") AND ("ESG" OR "Environmental, Social and Governance" OR "CSR" OR "Corporate Social Responsibility") AND ("Sustainability" OR "Sustainable Finance" OR "Sustainable Investing" OR "Sustainable Development" OR "Green Finance" OR "Responsible Investment")

Searches were conducted without date restrictions to capture the full historical development of the field. Only articles in English were included to maintain consistency across the dataset.

Inclusion and Exclusion Criteria

To ensure the relevance and quality of the dataset, a systematic screening process was applied using predefined inclusion and exclusion criteria, as illustrated in Figure 1.

- Inclusion Criteria:
    - Studies published in English that focus on the application of Artificial Intelligence (AI) in Environmental, Social, and Governance (ESG) analysis.
    - Papers that explore themes such as sustainability, accountability, transparency, or ethical investment through AI-driven approaches.
- Exclusion Criteria:
    - Publications that do not explicitly address the intersection of AI and ESG (e.g., those discussing only general AI applications or ESG frameworks without any AI component).

- Duplicates identified across the two databases (Scopus and Web of Science) were carefully removed.

Following this multistage screening process, 26 duplicates were eliminated, resulting in a final dataset of 581 relevant documents from 2005 to 2025 used for the bibliometric analysis presented in the following sections.

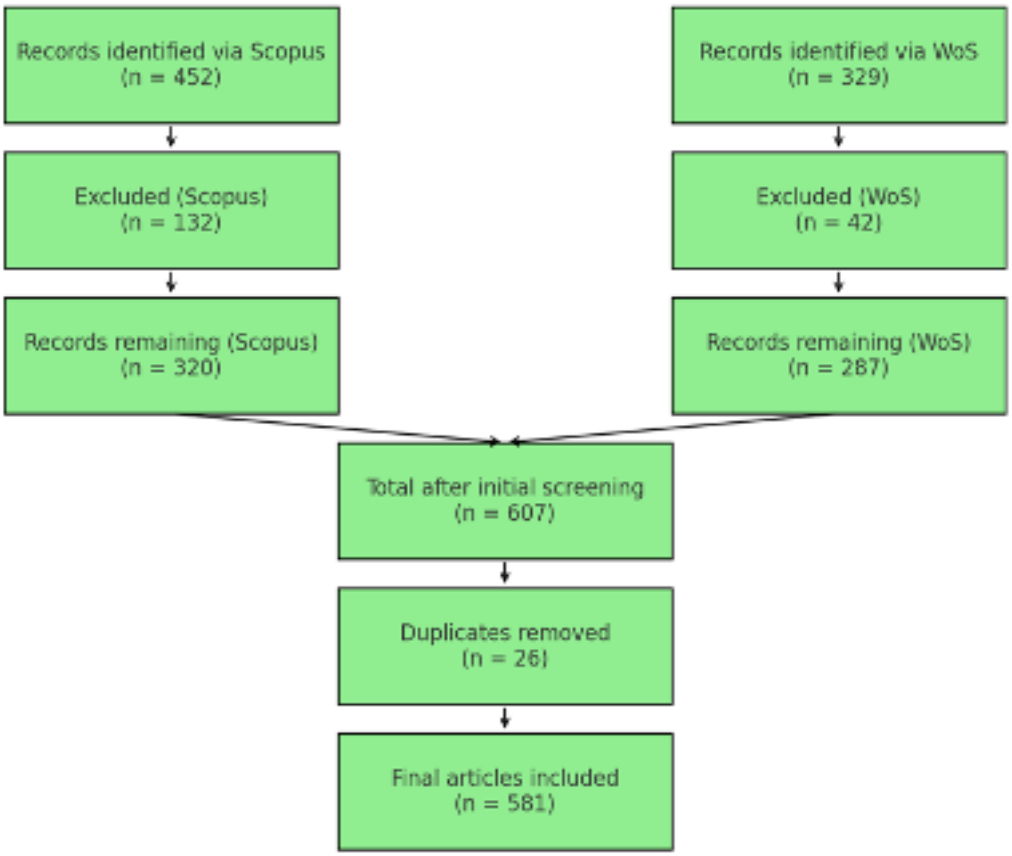

Figure1. Flowchart for the Bibliometric Analysis of AI-Driven ESG Research

FINDINGS

Publication by year

As shown in Figure 2, scholarly interest in AI-driven ESG research has expanded notably over the past two decades. From 2005 to 2014, publication output remained low. A marked increase began in 2015, driven by global initiatives such as the UN Sustainable Development Goals and the Paris Agreement.

Since 2018, the literature has grown rapidly, peaking in 2024 with 228 publications. This surge reflects the rise of AI adoption in ESG reporting and the influence of frameworks like the European Green Deal (Twinamatsiko & Kumar, 2022). As of January 2025, 16 publications were recorded. This apparent

decline should be interpreted cautiously, as it likely reflects the partial data coverage for the year rather than a real decrease in research activity.

These trends underscore the increasing role of AI in supporting ESG accountability and sustainable finance.

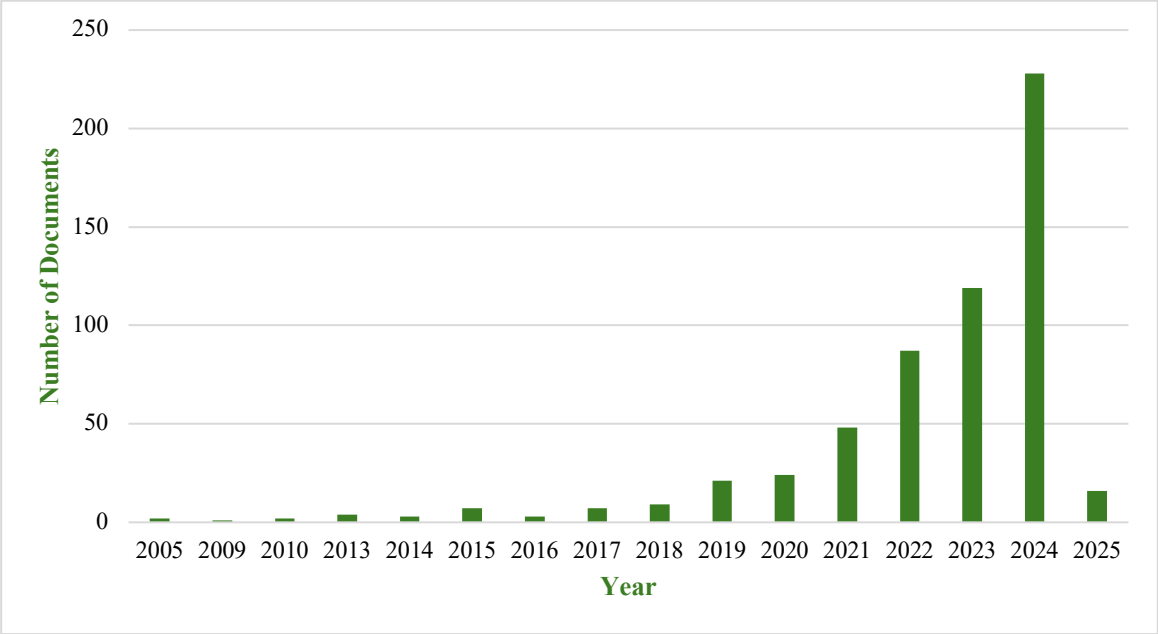

Figure 2. Classification of publications over time

Key Publishing Sources

Table 1 presents the top 10 journals contributing to AI-driven ESG research, reflecting the field's interdisciplinary scope. *Sustainability* leads with 87 publications and 1,179 citations, underscoring its central role in ESG discourse. *Lecture Notes in Networks and Systems* ranks second with 16 papers and 7 citations.

High-impact contributions are evident in *Annals of Operations Research* (7 publications, 429 citations) and *Procedia Computer Science* (5 publications, 101 citations), indicating the integration of AI into operational and computational frameworks. Journals like *Expert Systems with Applications* (4 publications, 53 citations) and *Clean Technologies and Environmental Policy* (4 publications, 33 citations) reflect the practical application of AI in advancing ESG practices across sectors.

Table1. Leading Journals by documents and citations

Journal Name	Documents	Citations
Sustainability	87	1179
Lecture Notes in Networks and Systems	16	7
Annals of Operations Research	7	429
ACM International Conference Proceeding Series	6	0
Meditari Accountancy Research	5	5
IFIP Advances in Information and Communication Technology	5	11
Energies	5	22
Procedia Computer Science	5	101
Expert Systems with Applications	4	53
Clean Technologies and Environmental Policy	4	33

Leading countries

As illustrated in Figure 2, research on AI applications in ESG analysis spans 90 countries, underscoring its global significance. The network of international collaborations reflects a shared commitment to leveraging AI in addressing sustainability challenges.

India leads in publication volume (69), reflecting its proactive integration of AI in development and sustainability agendas. The United States follows with 52 publications and the highest citation count (729), highlighting its strength in high-impact research backed by advanced infrastructure and institutional support. The United Kingdom (37 publications) ranks third, reinforcing its global role in sustainable finance and AI-driven innovation.

China, with 32 contributions, demonstrates a strategic focus on AI and sustainability as pillars of long-term national policy. European countries show strong participation, led by Italy (26), Germany (14), France (11), Portugal (9), and Spain (9), reflecting their alignment with initiatives such as the European Green Deal.

Emerging economies, including Malaysia (17), Saudi Arabia (16), South Korea (13), and South Africa (11), also contribute meaningfully, offering diverse perspectives on applying AI to ESG issues within rapidly evolving socio-economic contexts.

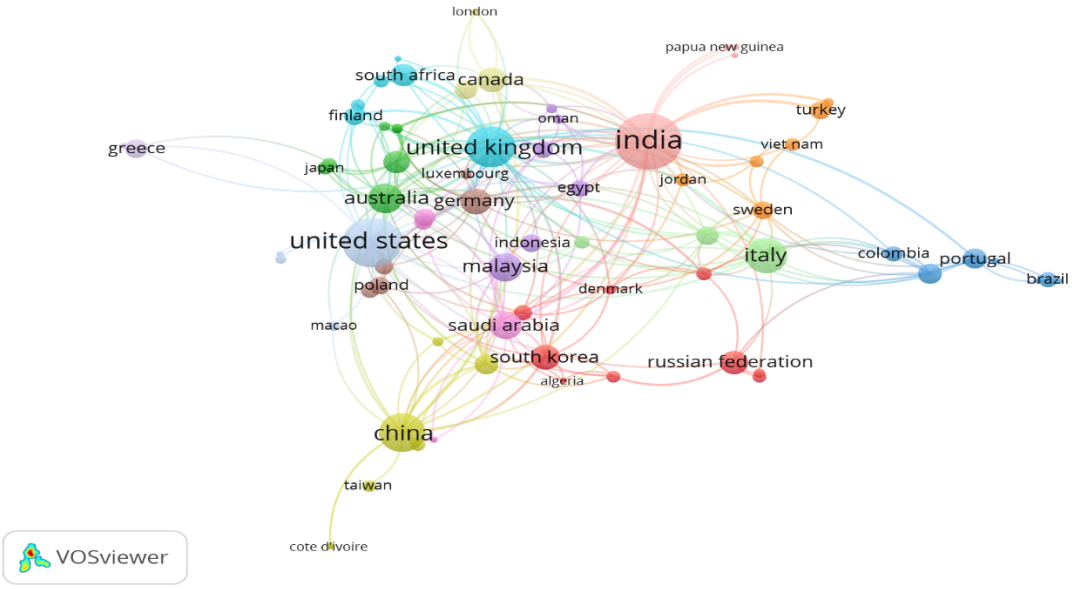

Figure. 2. Analysis of publications by countries

Keyword Co-occurrence and Emerging Topics

Using VOSviewer's co-occurrence mapping with a minimum threshold of five occurrences, we generated a temporal visualization that highlights three dimensions:

-The frequency of each keyword (indicated by node size)

-The recency of the term's appearance in the literature (represented by color gradients)

-The strength of association between keywords (reflected by proximity and linkage).

As shown in Figure 3, this method helps trace emerging themes, often referred to as the "research front", and provides insights into the intellectual connectivity of the domain.

The analysis reveals that "Artificial Intelligence" (173 occurrences) anchors the research landscape, affirming its central role in advancing ESG practices. Keywords such as "Risk Management" (151) and "Risk Assessment" (67) indicate a strong emphasis on predictive capabilities and mitigation strategies. Themes like "Sustainability" (135) and "Sustainable Development" (104) suggest alignment with global agendas such as the UN Sustainable Development Goals. Technological drivers like "Machine Learning" (106) and "Big Data" (22) highlight methodological advancements, while terms such as "Decision-Making" (40) and "Decision Support Systems" (18) point to AI's role in guiding ESG-oriented strategic decisions.

The temporal layer of the map indicates increased recent focus on topics such as "Digital Transformation", "Sustainability", and "Climate Risk", signaling a shift toward more actionable, transparent, and compliance-driven ESG frameworks supported by AI innovations.

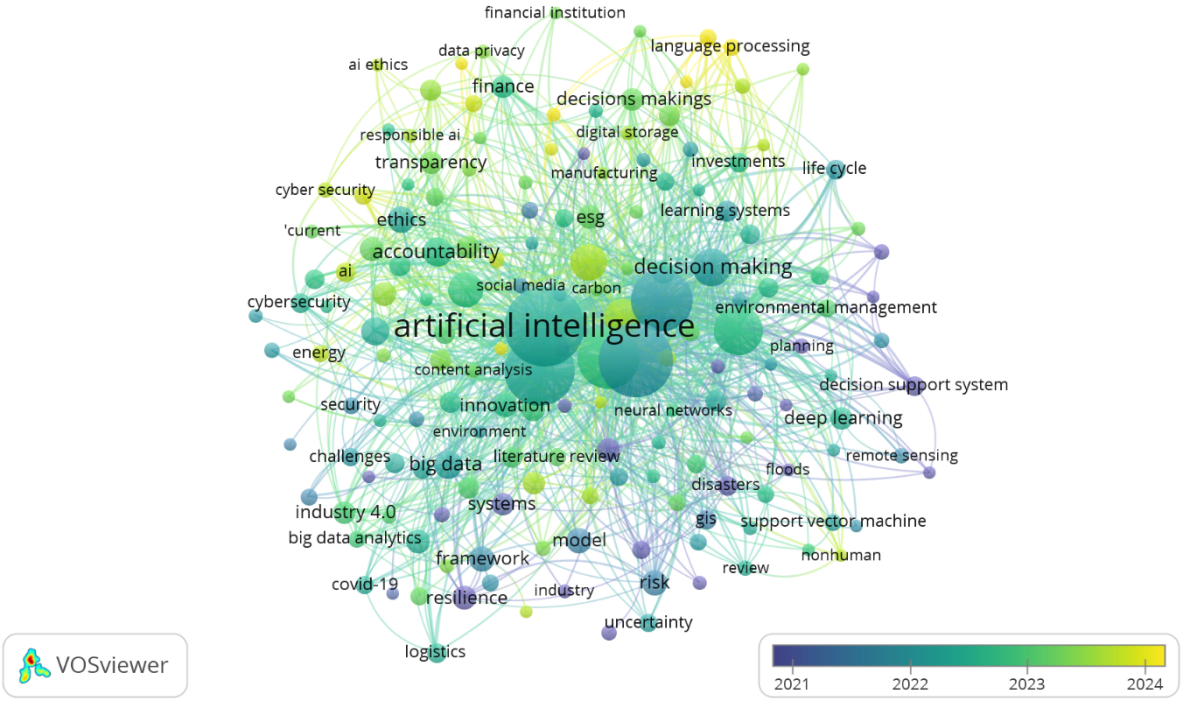

Figure 3. Evolution of keywords over years

Thematic Cluster Analysis

The cluster map, as shown in Figure 4, identifies four major themes in AI-driven ESG research, reflecting the field's diversity and growing complexity:

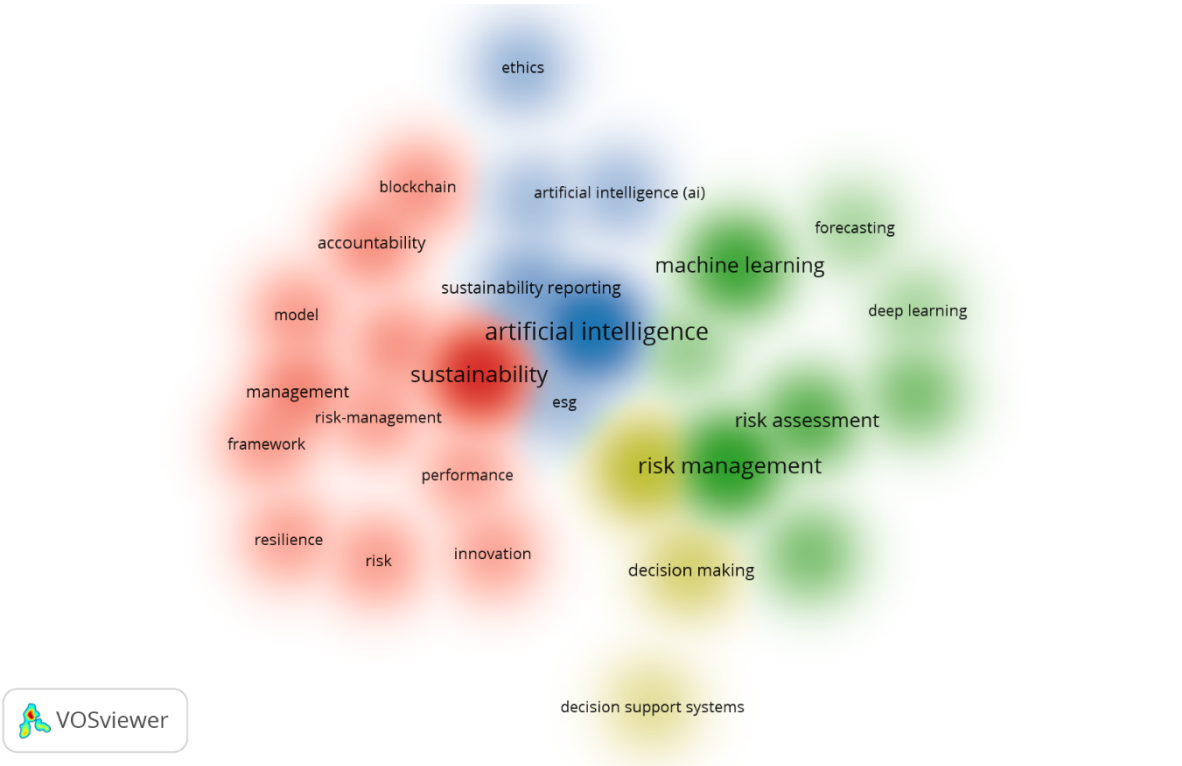

Figure 4. Keywords cluster map

Cluster 1: AI and Technological Innovation for ESG Accountability and Transparency

This theme centers on the integration of AI, blockchain and big data to improve ESG transparency and performance. AI methods such as machine learning and natural language processing are increasingly used to analyze ESG disclosures, identify reporting gaps, and enhance predictive risk assessment (Twinamatsiko & Kumar, 2022). Blockchain ensures traceable and secure ESG reporting (Singh & Bhasin, 2024), while big data enables real-time analysis of environmental and social metrics (Garrigós-Simón et al., 2021). Together, they support better compliance and reduce risks such as greenwashing (Yu, 2024).

Cluster 2: AI for Climate Strategies and Risk Management

This cluster highlights the role of machine learning, deep learning, and forecasting tools in identifying ESG risks and enabling climate-resilient strategies. Applications include predictive analytics for climate events (Awijen et al., 2024), satellite image analysis for environmental monitoring (Ma et al., 2019), and long-term forecasting for resource planning (Zhou et al., 2016).

Cluster 3: Digital Transformation through AI and Ethical ESG Practices

This area focuses on AI's contribution to automating ESG reporting and enhancing transparency. Techniques such as NLP and IoT feed into AI platforms that monitor and assess ESG performance in real time (Gutierrez-Bustamante & Espinosa-Leal, 2022). Ethical AI use is also emphasized to ensure fairness and accountability in decision-making (Lee et al., 2024).

Cluster 4: AI-Supported Decision-Making Systems to Achieve ESG Objectives

This cluster explores AI decision tools that guide organizations in optimizing ESG strategies. These systems support resource allocation, compliance planning, and social equity by using predictive models to align operations with sustainability goals and governance standards (Rane et al., 2024; Sklavos et al., 2024).

CONCLUSIONS

This study presents a comprehensive bibliometric review of how AI contributes to the evolution of ESG analysis. Based on a corpus of 581 publications sourced from Scopus and Web of Science, the results reveal a growing global engagement with AI-driven ESG research, led by countries such as India, the United States, and the United Kingdom. The thematic and cluster analyses highlight four core areas shaping the field: the use of emerging technologies like blockchain and big data for ESG accountability, AI-based climate risk management, digital transformation in ESG reporting, and intelligent decision support systems. These domains underscore the interdisciplinary nature of current research and the increasing reliance on AI to meet complex environmental, social, and governance challenges.

While the study offers a structured overview of current trends, it is limited by its focus on English-language sources. Expanding the scope to include non-English literature in future work would enhance the global representation of ESG-related AI research.

For practitioners, the findings offer strategic insights into how AI technologies can reinforce transparency, enhance data-driven decision-making, and support regulatory compliance within ESG frameworks. By leveraging machine learning, natural language processing, and big data analytics, organizations can improve the accuracy of ESG reporting, detect potential risks in real time, and align their operations with evolving sustainability standards. To ensure trustworthy outcomes, it is essential to implement responsible AI practices, including ethical audits and safeguards against data manipulation. This technological integration not only strengthens corporate accountability but also facilitates more informed stakeholder engagement and long-term value creation. For researchers, the identified trends such as ethical AI integration, climate adaptation, and technology convergence offer a roadmap for further empirical exploration.

By mapping the intellectual structure of this rapidly developing field, this work lays the groundwork for future interdisciplinary collaboration that seeks to align AI innovation with sustainable development goals.

REFERENCES

Awijen, H., Ben Jabeur, S., & Pillot, J. (2024). Interpretable machine learning models for ESG stock prices under transition and physical climate risk. *Annals of Operations Research*. https://doi.org/10.1007/s10479-024-06231-x

Boppiniti, S. T. (2023). Data Ethics in AI : Addressing Challenges in Machine Learning and Data Governance for Responsible Data Science. *International Scientific Journal for Research*, *5*(5), Article 5. https://isjr.co.in/index.php/ISJR/article/view/257

Božić, V. (2023). *ENVIRONMENTAL, SOCIAL, AND GOVERNANCE APPROACH (ESG) & ARTIFICAL INTELLIGENCE (AI)*. https://doi.org/10.13140/RG.2.2.34753.12641

Di Vaio, A., Palladino, R., Hassan, R., & Escobar, O. (2020). Artificial intelligence and business models in the sustainable development goals perspective : A systematic literature review. *Journal of Business Research*, *121*, 283-314. https://doi.org/10.1016/j.jbusres.2020.08.019

Donthu, N., Kumar, S., Mukherjee, D., Pandey, N., & Lim, W. M. (2021). How to conduct a bibliometric analysis : An overview and guidelines. *Journal of Business Research*, *133*, 285-296. https://doi.org/10.1016/j.jbusres.2021.04.070

Ellegaard, O. (2018). The application of bibliometric analysis : Disciplinary and user aspects. *Scientometrics*, *116*(1), 181-202. https://doi.org/10.1007/s11192-018-2765-z

Garrigós-Simón, F., Sanz-Blas, S., Narangajavana, Y., & Buzova, D. (2021). The Nexus between Big Data and Sustainability : An Analysis of Current Trends and Developments. *Sustainability*, *13*(12), Article 12. https://doi.org/10.3390/su13126632

Gomes, A., & Karim, M. (2024). *DATA-DRIVEN ENVIRONMENTAL RISK MANAGEMENT AND SUSTAINABILITY ANALYTICS*. https://doi.org/10.70008/jmldeds.v1i01.46

Goralski, M. A., & Tan, T. K. (2020). Artificial intelligence and sustainable development. *The International Journal of Management Education*, *18*(1), 100330. https://doi.org/10.1016/j.ijme.2019.100330

Gutierrez-Bustamante, M., & Espinosa-Leal, L. (2022). Natural Language Processing Methods for Scoring Sustainability Reports—A Study of Nordic Listed Companies. *Sustainability*, *14*(15), Article 15. https://doi.org/10.3390/su14159165

Ionescu, R. (2025). Adopting Cloud Computing and Big Data Analytics to Enhance Public Sector Transparency and Accountability Through Artificial Intelligence. *Nuvern Machine Learning Reviews*, *2*(1), Article 1.

Kalusivalingam, A. K., Sharma, A., Patel, N., & Singh, V. (2022). Enhancing Corporate Governance and Compliance through AI : Implementing Natural Language Processing and Machine Learning Algorithms. *International Journal of AI and ML*, *3*(9), Article 9. https://cognitivecomputingjournal.com/index.php/IJAIML-V1/article/view/73

Kim, B., Park, J., & Suh, J. (2020). Transparency and accountability in AI decision support : Explaining and visualizing convolutional neural networks for text information. *Decision Support Systems*, *134*, 113302. https://doi.org/10.1016/j.dss.2020.113302

Ma, L., Liu, Y., Zhang, X., Ye, Y., Yin, G., & Johnson, B. A. (2019). Deep learning in remote sensing applications : A meta-analysis and review. *ISPRS Journal of Photogrammetry and Remote Sensing*, *152*, 166-177. https://doi.org/10.1016/j.isprsjprs.2019.04.015

Oladoyinbo, T. O., Olabanji, S. O., Olaniyi, O. O., Adebiyi, O. O., Okunleye, O. J., & Ismaila Alao, A. (2024). *Exploring the Challenges of Artificial Intelligence in Data Integrity and its Influence on Social Dynamics* (SSRN Scholarly Paper No. 4693987). Social Science Research Network. https://papers.ssrn.com/abstract=4693987

Rane, N., Choudhary, S., & Rane, J. (2024). *Artificial intelligence driven approaches to strengthening Environmental, Social, and Governance (ESG) criteria in sustainable business practices : A*

review (SSRN Scholarly Paper No. 4843215). Social Science Research Network. https://doi.org/10.2139/ssrn.4843215

Singh, B. R., & Bhasin, N. K. (2024). Adoption of Blockchain in ESG (Environmental, Social, and Governance). In *Sustainability Reporting and Blockchain Technology*. Routledge.

Sklavos, G., Theodossiou, G., Papanikolaou, Z., Karelakis, C., & Ragazou, K. (2024). Environmental, Social, and Governance-Based Artificial Intelligence Governance : Digitalizing Firms' Leadership and Human Resources Management. *Sustainability*, *16*(16), Article 16. https://doi.org/10.3390/su16167154

Twinamatsiko, E., & Kumar, D. (2022). Incorporating ESG in Decision Making for Responsible and Sustainable Investments using Machine Learning. *2022 International Conference on Electronics and Renewable Systems (ICEARS)*, 1328-1334. https://doi.org/10.1109/ICEARS53579.2022.9752343

Vashishth, T. K., Sharma, V., Sharma, K. K., Kumar, B., Chaudhary, S., & Panwar, R. (2024). Intelligent Resource Allocation and Optimization for Industrial Robotics Using AI and Blockchain. In *AI and Blockchain Applications in Industrial Robotics* (p. 82-110). IGI Global Scientific Publishing. https://doi.org/10.4018/979-8-3693-0659-8.ch004

Yu, T. (2024). Blockchain Technology and the Improvement of ESG Information Transparency. In *Disruptive Human Resource Management* (p. 211-219). IOS Press. https://doi.org/10.3233/ATDE240431

Zhou, K., Fu, C., & Yang, S. (2016). Big data driven smart energy management : From big data to big insights. *Renewable and Sustainable Energy Reviews*, *56*, 215-225. https://doi.org/10.1016/j.rser.2015.11.050