




The Sustainable Effects of Blockchain and AI in Supporting ESG Goals

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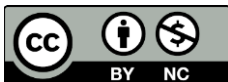
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ABSTRACT

This study investigates research trends on the integration of blockchain and artificial intelligence (AI) into Environmental, Social, and Governance (ESG) objectives through a bibliometric analysis of 358 publications indexed in the Web of Science from 2015 to 2025. The results reveal an accelerating research trajectory, with a sharp rise after 2020, reflecting the growing importance of digital technologies in sustainability discourse. Business and Economics dominate the field, followed by Environmental Sciences and technical disciplines, while social equity goals remain underexplored. Sustainable Development Goal (SDG) mapping shows strong alignment with SDG 9 (Industry, Innovation, and Infrastructure) and SDG 8 (Decent Work and Economic Growth), whereas goals such as poverty reduction and gender equality receive minimal attention. Geographically, China and the United States lead contributions, with Europe and emerging economies showing expanding engagement. Keyword co-occurrence analysis uncovers eight thematic clusters, spanning financial innovation, digital transformation, governance, performance measurement, ethics, and technological opportunities. Together, these findings reveal a shift from conceptual ESG discussions to technology-enabled implementation, highlighting both opportunities and research gaps. The study provides a roadmap for future interdisciplinary research and offers guidance for policymakers and practitioners seeking to harness blockchain and AI to advance global sustainability.

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1. INTRODUCTION

Sustainable development is increasingly framed as a global imperative, fostering the pursuit of innovative strategies to align with Environmental, Social, and Governance (ESG) objectives. As

organizations and governments strive to enhance resilience, transparency, and societal value, the intersection of advanced digital technologies, specifically blockchain and artificial intelligence (AI), emerges as a vital domain. Blockchain enables immutable, transparent, and auditable

data processes, while AI offers powerful capabilities in data analytics, predictive modeling, and optimization of complex systems. When combined, these technologies hold transformative potential for ESG-driven innovations, reshaping how sustainability performance is measured, verified, and enhanced.

Despite this promise, the extant literature remains scattered. Studies often focus narrowly on either blockchain or AI, emphasizing technological capabilities rather than their collective impact on ESG. There is a noticeable paucity of systematic syntheses that capture the global intellectual structure or collaborative patterns of research in this field. This gap is further pronounced in emerging economies, such as Vietnam, where research remains largely theoretical and unaligned with evolving global trends.

Research on the application of blockchain and AI in supporting ESG objectives has achieved significant milestones [1]. Numerous international studies have emphasized the role of blockchain in enhancing data transparency and improving traceability in supply chain management. At the same time, AI has been recognized for its ability to analyze and predict trends based on big data, thereby supporting the optimization of operational processes and reducing negative environmental impacts [2]. Moreover, ESG is not only a goal for businesses and organizations but also a central focus of global sustainable development strategies. In this context, further investigation into the relationship between blockchain, AI, and ESG is urgently needed. Through bibliometric analysis, research can not only systematize existing findings but also uncover knowledge gaps, identify emerging trends, and provide practical recommendations for businesses, policymakers, and the scientific community.

In the context of globalization and mounting pressure for sustainable development, research on technological solutions that support ESG objectives is not only an urgent necessity but also a strategic priority for organizations and nations. Blockchain and AI are two pioneering technologies that have demonstrated exceptional potential in enhancing transparency, efficiency, and decision-making capacity. However, existing studies primarily examine each technology in isolation, lacking integration and systematization of their relationship with ESG.

The implementation of this research is both necessary and urgent, particularly when guided by modern scientific methods such as bibliometric analysis. Bibliometric methods not only allow for a comprehensive assessment of the global research landscape but also help to identify knowledge gaps, emerging trends, and interdisciplinary linkages in the field of blockchain, AI, and ESG [3]. This approach ensures objectivity and scientific rigor in collecting, processing, and presenting data from reliable sources [4].

The application of bibliometric analysis further provides a holistic framework to evaluate the impact of technology on different aspects of ESG. It enables the detection of major research themes, influential authors and organizations, as well as the level of collaboration between countries and disciplines [5]. Accordingly, this method not only clarifies the relationship between blockchain, AI, and ESG but also highlights research domains requiring further development, especially in interdisciplinary areas.

Bibliometric analysis also holds strong practical significance. It provides quantitative evidence to support policymakers, businesses, and researchers with comprehensive and well-grounded insights for making strategic decisions [6]. This method facilitates the analysis of technological implementation potential, the identification of contextual barriers, and the formulation of suitable solutions to optimize ESG performance in the context of international integration.

Furthermore, this study aligns with the orientation of applied scientific development at the University by employing modern methodologies to address both theoretical and practical issues. Bibliometric analysis not only ensures scientific rigor but also strengthens the implementation of interdisciplinary research, affirming the role of scholarship in tackling global challenges. This study is novel and innovative due to its application of bibliometric analysis to synthesize and evaluate existing research on the intersection of blockchain technology, artificial intelligence (AI), and ESG objectives. This approach provides a comprehensive perspective on the relationship among these three elements—a topic that remains relatively new and underexplored within the scientific community. Most existing studies focus on analyzing blockchain or AI separately in specific

applications, or on examining the influence of individual ESG dimensions [7]. Recent bibliometric studies offer compelling precedents. For example, Davidescu (2025) conducted a bibliometric analysis spanning AI, ESG, and Sustainable Finance, revealing rapid growth in AI applications for ESG risk modeling, climate analytics, and reporting post-2015. Similarly, Ekaristi (2025) demonstrated how AI and Big Data enhance ESG performance measurement, highlighting AI's role in anomaly detection and real-time analytics, while also calling for integration with blockchain and alternative data sources [8]. Additionally, Shedding light on ESG research trends broadly, another bibliometric investigation identified hot topics such as ESG factors, investing, disclosure, and outcomes across 755 WoS publications, illustrating thematic hotspots and research evolution [9]. However, very few investigations offer an integrated view of how blockchain and AI collectively advance ESG, particularly at the global level. Consequently, this research not only adds value to the existing body of knowledge but also broadens and clarifies the current research gaps.

The creativity of this study is further reflected in its construction of a synthesized theoretical framework, drawing on findings from multiple authors, countries, and institutions, to evaluate the sustainable effectiveness of blockchain and AI in achieving ESG goals. Bibliometric analysis facilitates the identification of core research themes, influential scholars, organizational linkages, and international collaboration trends [10]. This not only illuminates the overall landscape of the field but also equips researchers, businesses, and policymakers with deeper insights into the effectiveness and potential of integrating technology into sustainable development strategies.

Another innovative aspect of this study lies in its exploration of the practical applications of blockchain and AI in optimizing ESG objectives—an area that has not been sufficiently examined in most prior works. By leveraging bibliometric methods, this research identifies emerging research trends, success factors, and barriers to implementing these technologies in practice, particularly within corporate governance and public policy domains. Combining theoretical and practical insights from global research enables the study to propose concrete, feasible, and applicable solutions for enhancing ESG performance

Building on these foundations, the present study applies bibliometric techniques to assess the sustainable impacts of blockchain and AI in supporting ESG goals, covering publications indexed in the Web of Science from 2015 onward. The specific aims are to: First, mapping global research trends and highlight influential contributions through citation and publication analysis, thereby discerning which studies and authors have shaped scholarly discourse; Second, uncovering thematic structures and emerging topics by utilizing keyword co-occurrence, co-citation, and cluster analyses, to reveal areas of heightened academic activity and future directions; Third, evaluating collaboration networks among authors, institutions, and countries using co-authorship and bibliographic coupling analyses, shedding light on interdisciplinary and cross-border partnerships; Fourth, identifying knowledge gaps and offer research pathways, contributing both to the international scholarly dialogue on sustainable innovations and to the strategic positioning of blockchain–AI–ESG integration in Vietnam.

2. LITERATURE REVIEW

2.1. Bibliometric Studies on Blockchain and AI Integration

Recent bibliometric reviews have shed light on the convergence of blockchain and artificial intelligence (AI) across different domains. For instance, Alaeddini et al. applied scientometric methods to analyze 505 articles on AI–blockchain convergence in smart cities, revealing key research hotspots, collaborative networks, and emerging themes [11].

Similarly, a bibliometric study focusing on the Edge of Things (EoT) environment evaluated the convergence of AI and blockchain from 2018 to 2023. It identified research trends, influential authors and institutions, and revealed emerging areas within this interdisciplinary field [12].

Valencia-Arias and colleagues conducted a bibliometric investigation into the intersection of machine learning and blockchain with a focus on security and privacy, using a PRISMA-2020-based analysis of Scopus and Web of Science data to extract publication trends, and geographic research leaders [13].

2.2. Bibliometric Reviews in Related Contexts

Beyond the AI–blockchain intersection, bibliometric analyses have been employed in related fields such as ESG and sustainable technologies. Mukhtar et al. integrated systematic literature review with bibliometric analysis to examine ESG literature spanning 2007–2022. They applied performance analysis, science mapping, and network analysis to identify influential publications and thematic clusters, introducing a novel Theory–Context–Characteristics–Methods framework [14].

Alqudah et al. applied cluster-based bibliographic coupling methods to 1,603 papers focusing on ESG-related sustainable technologies. Their analysis uncovered four significant research clusters, including sustainable AI and FinTech.

2.3. Blockchain and AI in Functional Domains

Outside ESG-focused literature, bibliometric approaches have been applied to analyze blockchain and AI across specific functional domains:

In auditing, Abu Huson et al. reviewed 328 articles on information technology, AI, and blockchain—analyzing publishing trends, key topics, and contributor networks using VOSviewer [15].

In management, a bibliometric review highlighted the application of blockchain in managerial practices through co-citation clustering and dynamic co-citation analysis, uncovering themes like strategy, regulation, and inefficiencies [16].

Jannah et al. conducted a bibliometric study on environmental accounting in the era of AI and blockchain (2009–2023), noting limited research and calling for future direction setting [17].

In renewable energy systems, a bibliometric review of AI, IoT, and blockchain in energy infrastructures identified publication trends and technology-specific application areas, using VOSviewer and MATLAB for visualization and statistical analysis [18].

3. RESEARCH METHODOLOGY

To examine the relationship between blockchain, artificial intelligence (AI), and Environmental, Social, and Governance (ESG) objectives, this study primarily employs bibliometric analysis. This method enables the synthesis, analysis, and evaluation of existing research in the field of blockchain, AI, and ESG, thereby clarifying prevailing trends, linkages, and research gaps.

3.1 Data collection

The study collects scientific articles, books, reports, and relevant research outputs on blockchain, AI, and ESG from reputable scientific databases such as Web of Science. By gathering articles and reports from these sources, the study aims to identify current research trends, influential authors, key research institutions, and “hot topics” related to the application of technology in ESG.

The search string was constructed to capture variations in terminology and spelling, and was applied to the Topic field (covering title, abstract, author keywords, and Keywords Plus). The specific query used was:

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TS = ("ESG" OR "Environment, Social and Governance")
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AND
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TS = ("Blockchain" OR "Block chain" OR "Blockchain" OR "Distributed ledger" OR "AI" OR "Artificial Intelligence").
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This search was limited to the period from 2015 to August 2025, reflecting the rapid emergence and increasing relevance of blockchain and AI in ESG research during this timeframe. Only peer-reviewed articles, conference papers, and reviews were included to ensure academic rigor, while book chapters, editorials, and non-scholarly sources were excluded. The final collected data is 358 publications.

The search results were then screened to remove duplicates and irrelevant studies, followed by data cleaning to standardize author names, institutional affiliations, and keywords. The final dataset served as the foundation for subsequent bibliometric analyses, enabling the identification of influential publications, research trends, thematic clusters, and collaboration networks.

3.2 Analytical tools

The collected data will be analyzed using bibliometric software such as VOSviewer (version 1.6.20). This analysis helps to identify relationships among topics, keywords, authors, and organizations, while also detecting prominent research areas and knowledge gaps. Bibliometric indicators such as publication counts, citation numbers, author and institutional impact will be applied to evaluate the development and maturity of this research domain.

3.3 Analytical methods

Three principal bibliometric techniques will be employed in this study: Citation Analysis, Co-authorship Analysis, and Co-occurrence Analysis. Each method plays a crucial role in constructing an overall picture of the integration between blockchain, AI, and ESG.

Citation Analysis

Citation analysis evaluates the influence and importance of publications within the field. It identifies works that have significantly shaped the development of blockchain, AI, and ESG research. This method considers indicators such as the H-index, average citations, and highly cited papers to highlight core contributions and reveal knowledge gaps for future exploration [19].

Co-authorship Analysis

Co-authorship analysis uncovers collaboration patterns among authors, institutions, and countries in blockchain, AI, and ESG research. By mapping these networks, it reveals key scholars, research groups, and collaborative hubs. Tools such as VOSviewer or Gephi will be used to visualize collaboration networks, thereby identifying leading organizations and countries central to this field [20].

Co-occurrence Analysis

Co-occurrence analysis identifies major research themes and emerging topics within the literature. By examining the frequency and co-occurrence of keywords, this method groups related terms into clusters and constructs keyword maps. Using VOSviewer, the analysis visualizes interconnections among topics, thereby uncovering dominant research areas and emerging trends in blockchain, AI, and ESG [10].

4. RESULTS AND DISCUSSIONS

4.1 Data analysis

The trend of publications from 2015 through 2025 in the blockchain, AI, and ESG space shows a rapid increase in scholarly activity, particularly from 2019 onward (Figure 1). Early years (2015–2018) saw very few contributions, but after 2019 the numbers accelerate sharply, reaching a peak in 2024. This pattern mirrors similar findings in bibliometric studies of blockchain in sustainable supply chains, which report limited output until ~2018 followed by significant growth in more recent years [21].

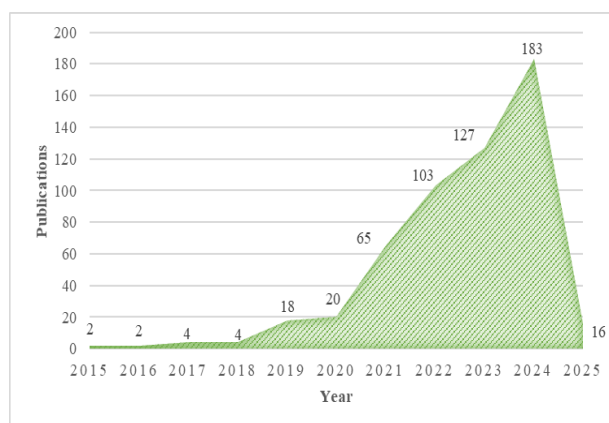


Fig. 1. Publication Trends over Time.

This surge likely reflects increasing global emphasis on sustainability, transparency, and ESG frameworks. For example, studies report that AI adoption significantly enhances environmental and social performance within ESG metrics, particularly when organizational capabilities such as digital learning and effective management are present [22]. Additionally, research shows blockchain adoption contributes positively to sustainable development performance — including environmental transparency and social accountability — in corporate contexts [23].

The rapid growth in publications also corresponds with external events driving attention to ESG: the COVID-19 pandemic is one such event. Bibliometric analyses show that ESG research significantly expanded in the post-COVID period, especially in areas such as sustainability reporting, corporate strategy, and financial outcomes [24].

Together, these trends underscore that integrating blockchain and AI into ESG research is not just academically relevant but increasingly necessary for sustainable innovation. The accelerating publication rate suggests both demand and opportunity: demand from stakeholders and regulators for ESG accountability, and opportunity for researchers to explore underdeveloped or emerging themes (e.g., governance impact of AI, combined use of blockchain + AI, specific regional studies).

The distribution of research areas is shown in Figure 2. Most publications (47.2%) are in the Business and Economics field, indicating that blockchain and AI are primarily studied in relation to corporate strategy, finance, and ESG reporting. This reflects the demand for transparency and sustainable business models [25].

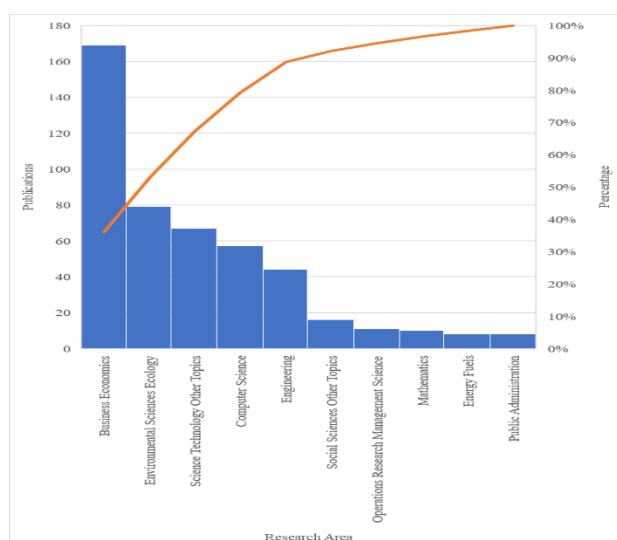


Fig. 2. The distribution of research areas.

The second largest share (22.1%) is Environmental Sciences, highlighting applications in carbon tracking, energy efficiency, and climate modeling. Both blockchain and AI are increasingly used to enhance environmental sustainability [2, 26].

Technology-related fields—Science & Technology (18.7%), Computer Science (15.9%), and Engineering (12.3%)—provide the technical foundations for these applications. Much of the innovation originates here before being adapted to business and environmental domains [11].

Smaller shares in Social Sciences, Public Administration, and Energy show that policy, governance, and energy efficiency are emerging but underrepresented areas. These fields are essential to address adoption barriers and blockchain’s own energy footprint [3, 10]. The results in Figure 3 show that SDG 9 dominates with 41.9% of publications. This reflects the central role of blockchain and AI as enablers of digital innovation and infrastructure for sustainable development [26]. The high share indicates that most research emphasizes technological integration to strengthen industrial systems and innovation capacity.

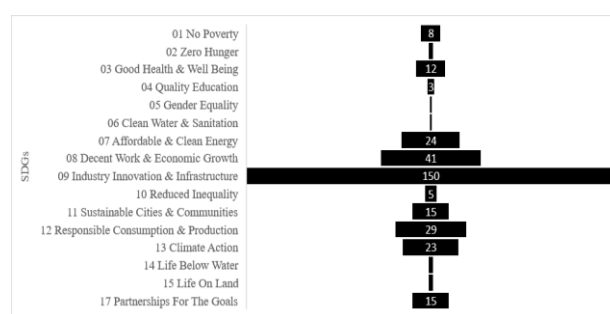


Fig. 3. The Sustainable Development Goals (SDGs) distribution.

SDG 8 (11.5%) and SDG 12 (8.1%) are also well represented. These findings align with studies highlighting that digital technologies improve labor productivity, supply chain efficiency, and resource optimization [2]. Environmental goals such as SDG 7 (6.7%) and SDG 13 (6.4%) demonstrate that blockchain and AI are increasingly applied to renewable energy markets, carbon tracking, and climate risk assessment [10].

In contrast, social dimensions such as SDG 1 (2.2%), SDG 3 (3.4%), and SDG 5 (0.3%) receive limited attention. This imbalance shows that while technology-driven sustainability is advancing, issues of equity and inclusion remain underexplored [25].

Finally, SDG 11 (4.2%) and SDG 17 (4.2%) suggest growing recognition of interdisciplinary and collaborative approaches. These areas are essential to integrate blockchain and AI into broader sustainability transitions through governance and partnerships [3].

Top 10 countries with the highest publications describe on Figure 4. The results highlight China as the clear leader with 107 publications, reflecting its strong policy support and investment in blockchain, AI, and sustainability research [27]. The USA follows with 48, focusing largely on business and financial ESG applications [28]. European countries such as England, Italy, and Spain make notable contributions, influenced by the EU’s regulatory push on ESG and sustainable innovation [25]. Meanwhile, emerging economies like India and Malaysia are increasingly active, applying these technologies to supply chain transparency, smart cities, and financial inclusion [3].

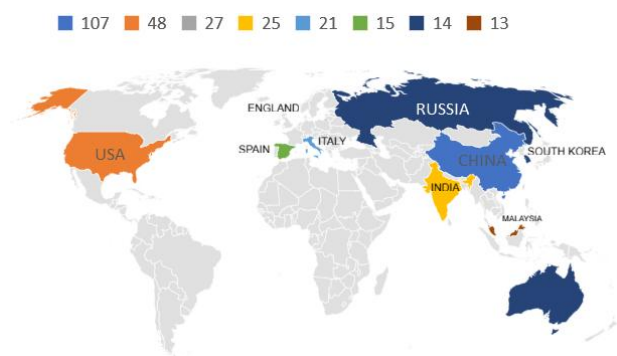


Fig. 4. Top 10 countries with the highest publications.

This distribution shows that technologically advanced economies dominate, but the growing participation of emerging regions indicates a trend toward global diffusion. However, disparities remain: while China and the USA drive technological and business applications, contributions from developing countries are still limited, potentially widening the digital divide in ESG innovation. Strengthening international collaboration, particularly between advanced and emerging economies, could enhance inclusivity, ensure knowledge transfer, and accelerate progress toward global sustainability goals.

4.2 Citation analysis

The most influential papers can be grouped into four major themes. The first centers on sustainable entrepreneurship and ESG measurement. Mansouri (2022), with 113 citations, provides a comprehensive framework for assessing ESG measurement,

valuation, and performance in entrepreneurial contexts. This reflects the dominance of business- and finance-oriented research, where ESG is viewed as a driver of corporate sustainability and long-term value creation [29].

A second theme is technological innovation through Industry 4.0 and 5.0. Asif (2023), with 112 citations, examines how technologies contribute to ESG disclosure in the Industry 5.0 era [8], while De Giovanni (2023) highlights the sustainability implications of the Metaverse, earning 90 citations [30]. Similarly, Saxena (2023) discusses how Industry 4.0 technologies empower ESG practices. Collectively, these works underline the transition from automation-focused Industry 4.0 to a more human-centered, sustainability-driven Industry 5.0, where blockchain and AI become tools for enhancing transparency and accountability [31].

The third theme emphasizes AI’s role in sustainability and environmental accountability. Budenny (2022) introduces eco2AI, a framework for tracking the carbon emissions of machine learning models, with 66 citations [32]. Saxetra (2023) and Sætra (2021) advance this discussion by developing frameworks for evaluating AI’s ESG impacts and proposing the AI ESG protocol to systematize disclosure [31, 33]. Zhang (2024) further contributes by analyzing how AI can curb greenwashing in sustainable growth [34]. These studies highlight both the opportunities and risks of AI, positioning it as a powerful tool for sustainability while also recognizing the environmental costs of computational intensity.

A fourth theme relates to ESG ratings, sustainable investment, and supply chains. Hughes (2021) examines how technological innovation reshapes ESG ratings [35], while Chauhan (2023) focuses on the digitalization of supply chain management through Industry 4.0 technologies [36]. Together, these studies stress how blockchain and AI improve decision-making, investment credibility, and operational efficiency, thereby strengthening ESG outcomes across industries.

Table 1. Top publications with highest citations.

Title	1st Authors	Source Title	Year	Cite	Citation Average
Financing sustainable entrepreneurship: ESG measurement, valuation, and performance	Mansouri, Sasan	Journal of Business Venturing	2022	113	28,25
ESG and Industry 5.0: The role of technologies in enhancing ESG disclosure	Asif, Muhammad	Technological Forecasting & Social Change	2023	112	37,33
Sustainability of the Metaverse: A Transition to Industry 5.0	De Giovanni, Pietro	Sustainability	2023	90	30
eco2AI: Carbon Emissions Tracking of Machine Learning Models as the First Step Towards Sustainable AI	Budenny, S. A	Doklady Mathematics	2022	66	22
A Framework for Evaluating and Disclosing the ESG Related Impacts of AI with the SDGs	Saetra, Henrik Skaug	Sustainability	2021	62	12,4
Technologies Empowered Environmental, Social, and Governance (ESG): An Industry 4.0 Landscape	Saxena, Archana	Sustainability	2023	56	18,67
Alternative ESG Ratings: How Technological Innovation Is Reshaping Sustainable Investment	Hughes, Arthur	Sustainability	2021	54	10,8
The pathway to curb greenwashing in sustainable growth: The role of artificial intelligence	Zhang, Dongyang	Energy Economics	2024	53	26,5
Digitalization of Supply Chain Management with Industry 4.0 Enabling Technologies: A Sustainable Perspective	Chauhan, Sanjay	Processes	2023	53	17,67
The AI ESG protocol: Evaluating and disclosing the environment, social, and governance implications of artificial intelligence capabilities, assets, and activities	Saetra, Henrik Skaug	Sustainable Development	2023	46	11,5

4.3 Co-authorship results

The co-authorship network highlights several influential authors contributing to the intersection of blockchain, AI, and ESG. The color gradient (2023–2024) shows the temporal evolution of collaborations, with earlier contributions in darker blue and more recent ones in green to yellow (Figure 5).

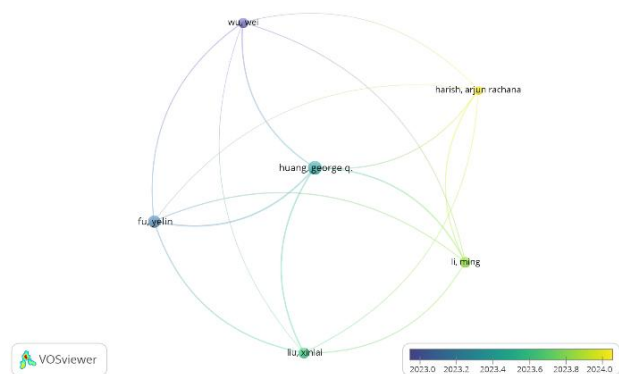


Fig. 5. Co-authorship analysis by author.

At the center of the network is Huang, George Q., who acts as a key connector among different scholars. His collaborations with Fu, Yelin, Liu, Xinlai, and Li, Ming suggest a strong cluster of Chinese researchers working collectively on sustainability-driven technology applications. This cluster represents one of the most active groups, with publications concentrated in 2023–2024.

Wu, Wei appears as another significant node, bridging connections between earlier and ongoing collaborations. Wu’s links to both Huang and Fu reflect continuity in partnerships that may have helped drive the field’s growth in 2023.

In contrast, Harish, Arjun Rachana represents a newer entry into the network, with publications appearing closer to 2024 (yellow). This suggests growing international involvement and possibly emerging collaborations beyond the Chinese-centered cluster.

4.4 Co-occurrence results

The keyword co-occurrence network provides valuable insights into the interrelationships among various concepts in the context of sustainability, particularly regarding the roles of Blockchain and Artificial Intelligence (AI) in supporting Environmental, Social, and Governance (ESG) goals (Figure 6). Each cluster identified in the visual representation highlights distinct yet interconnected themes that contribute to the overall understanding of how these technologies can drive sustainable practices (Table 2).

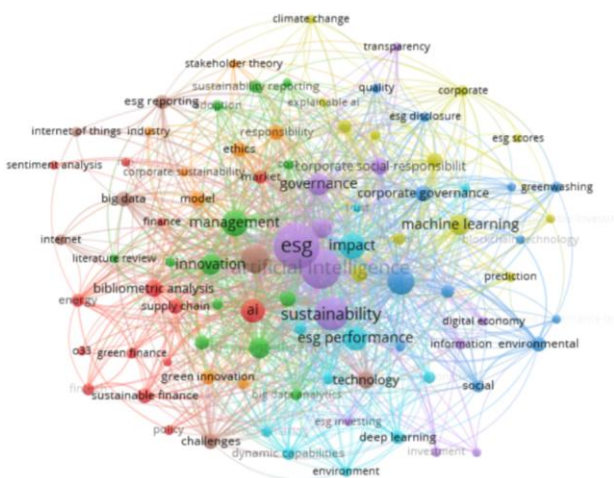


Fig. 6. Keyword co-occurrence analysis.

Cluster 1 (red): Financial and Policy Insights

This cluster contains keywords such as *AI, finance, green finance, and sustainable finance*. These terms suggest a strong emphasis on the financial mechanisms that support sustainability initiatives. The presence of policy and market indicates that regulatory frameworks and market dynamics play crucial roles in the adoption of sustainable practices. Moreover, sentiment analysis reflects the importance of public perception in shaping financial strategies. This cluster emphasizes the intersection of technology and finance, particularly how AI can facilitate innovative financial solutions in green finance.

Cluster 2 (green): Adoption and Digital Transformation

Keywords like *adoption, digital transformation, and big data analytics* populate this cluster, emphasizing the importance of integrating advanced technologies into business practices.

The presence of terms such as innovation and management indicates that organizations are increasingly recognizing the need to adapt to new technologies to enhance their ESG performance. The focus on ESG ratings and sustainability reporting systems suggests that effective reporting frameworks are essential for assessing and improving sustainability efforts. This cluster underscores the transformative potential of digital tools in advancing sustainability goals.

Cluster 3 (blue): Governance and Environmental Considerations

This cluster features keywords like *corporate governance, environmental, and ESG disclosure*. The emphasis on ownership and greenwashing highlights the challenges companies face in maintaining transparency and accountability in their sustainability claims. The inclusion of China suggests a geographical focus on how governance and environmental policies are evolving in different regions. This cluster reflects the critical need for robust governance frameworks to ensure that sustainability initiatives are effectively implemented and reported.

Cluster 4 (yellow): Performance Metrics and Risk Management

Keywords such as *climate change, financial performance, and ESG scores* dominate this cluster. The focus on machine learning and prediction indicates that data-driven approaches are essential for assessing and managing risks associated with sustainability. The presence of terms like explainable AI suggests a growing demand for transparency in AI-driven analyses, particularly regarding their impact on financial and environmental performance. This cluster highlights the importance of quantifying ESG performance and understanding the risks tied to sustainability initiatives.

Cluster 5 (purple): Sustainability and Corporate Responsibility

This cluster includes keywords like *corporate social responsibility, ESG investing, and sustainability*. The emphasis on transparency and information indicates that clear communication of ESG practices is vital for building trust with stakeholders. This cluster reflects a broader trend where companies

are increasingly aware of their responsibilities towards society and the environment. The focus on sustainable development further emphasizes the long-term vision needed to achieve meaningful ESG outcomes.

Cluster 6 (light blue): Business Practices and Impact

Keywords such as *CSR, decision-making, and dynamic capabilities* characterize this cluster. The emphasis on trust and impact highlights the importance of stakeholder engagement in the decision-making process. The presence of ESG performance and firm performance underscores the link between sustainable practices and business success. This cluster suggests that integrating ESG considerations into core business strategies can lead to better outcomes, both financially and socially.

Cluster 7 (orange): Ethical Considerations and Industry Practices

This cluster includes keywords like *corporate sustainability, ethics, and stakeholder theory*. The focus on green innovation indicates a growing recognition of the ethical responsibility's businesses have towards sustainable practices. The presence of responsibility and sustainable development suggests that organizations are increasingly held accountable for their environmental and social impacts. This cluster emphasizes the importance of ethical considerations in driving corporate sustainability efforts.

Cluster 8 (brown): Technological Challenges and Opportunities

The final cluster features keywords such as *big data, blockchain, and Internet of Things*. These terms highlight the technological landscape that supports ESG initiatives, as well as the challenges associated with implementing these technologies. The emphasis on ESG reporting indicates the need for technological solutions that facilitate accurate and transparent reporting. This cluster reflects the dual nature of technology in sustainability: while it offers significant opportunities for improvement, it also presents challenges that organizations must navigate.

The keyword co-occurrence analysis reveals a multifaceted view of how technology, governance, and sustainability intersect in the context of ESG goals. Each cluster provides insights into specific areas of focus, from financial mechanisms and digital transformation to ethical considerations and technological challenges. Together, these clusters illustrate the complexity of implementing effective ESG strategies and the critical role that innovative technologies, such as AI and blockchain, play in driving sustainable practices. Understanding these dynamics is essential for organizations aiming to enhance their sustainability performance and meet the evolving expectations of stakeholders.

Table 2. Keywords by clusters.

Cluster	Keywords	Occurrences	TLS
Red	AI	33	118
	Energy	10	39
	Finance	5	13
	Fintech	8	27
	Green finance	7	29
	Market	9	44
	NLP (Natural Language Processing)	5	19
	Policy	6	19
	Sentiment analysis	5	9
	Supply chain	13	51
Sustainable finance Trends	12	50	
Green	Adoption	7	22
	Artificial intelligence	87	280
	Big data analytics	7	45
	Cost	6	36
	Digital transformation	15	52
	ESG ratings	5	20
	Framework	11	60

	Future	6	34
	Innovation	25	101
	Management	38	182
	Sustainability reporting	9	31
	Systems	7	31
Blue	Artificial intelligence (AI)	10	33
	Blockchain technology	5	9
	China	6	24
	Corporate governance	14	61
	Environmental	13	48
	ESG disclosure	6	29
	Greenwashing	7	25
	Ownership	5	20
	Performance	40	172
	Quality	6	26
	Social	8	41
	Social and governance (S&G)	5	16
Yellow	Climate change	5	14
	Corporate	7	34
	Disclosure	12	60
	Environmental performance	6	33
	ESG scores	5	10
	Explainable AI	5	20
	Financial performance	10	70
	Machine learning	25	77
	Models	8	30
	Prediction	6	26
	Risk	15	71
	Socially responsible investing	5	28
Purple	Corporate social responsibility	7	42
	Digital economy	5	14
	ESG	116	351
	ESG investing	5	20
	Governance	27	144
	Information	7	29
	Investment	6	18
	Sustainability	62	237
	Sustainable development	22	76
	Sustainable investing	5	14
	Transparency	5	19
Light Blue	Business	7	41
	Decision-making	6	26
	Deep learning	9	31
	Dynamic capabilities	8	40
	Environment	6	32
	ESG performance	32	102
	Firm performance	5	31
	Impact	38	184
	Social responsibility	8	35
	Trust	5	22
Orange	Corporate sustainability	5	14
	Ethics	12	57
	Green innovation	11	44
	Industry	5	22
	Model	12	51
	Responsibility	12	53
	Stakeholder theory	5	23
	Sustainable development	13	53
Brown	Big data	13	53
	Blockchain	43	122
	Challenges	12	58
	ESG reporting	11	48
	Internet	7	25
	Internet of Things	6	18
	Technology	16	73

5. CONCLUSION

This study employed bibliometric analysis to explore the intersection of blockchain, artificial intelligence (AI), and Environmental, Social, and Governance (ESG) goals using data from 2015 to 2025. The findings highlight a sharp rise in academic interest after 2020, peaking in 2024, which reflects the growing recognition of these technologies as enablers of sustainable development.

The analysis of research areas reveals that Business and Economics dominate, followed by Environmental Sciences and technical fields such as Computer Science and Engineering. This indicates a strong focus on financial and operational applications of blockchain and AI, while social and governance dimensions remain underrepresented. SDG mapping further confirms this trend, with most research concentrated on SDG 9 (Industry, Innovation, and Infrastructure), alongside attention to economic growth (SDG 8), responsible consumption (SDG 12), and climate action (SDG 13). By contrast, poverty alleviation, equity, and health goals receive limited attention, signaling gaps in socially inclusive sustainability research.

Geographical analysis underscores China's dominance, followed by the USA and leading European countries, while emerging economies such as India and Malaysia are increasingly active. Co-authorship patterns suggest that research networks remain concentrated among a small set of leading scholars, though evidence of diversification and new international collaborations is emerging. Top-cited works cluster into four themes: ESG measurement and entrepreneurship, Industry 4.0/5.0 innovations, AI's environmental implications, and ESG ratings with supply chain digitalization, reflecting a shift from conceptual frameworks to technology-enabled ESG implementation.

The keyword co-occurrence network provides further insights into how concepts interconnect in this field. Eight thematic clusters emerged: (1) financial and policy insights, focusing on AI-driven green finance; (2) adoption and digital transformation, emphasizing big data, innovation, and ESG reporting; (3) governance and environmental considerations, addressing disclosure, greenwashing, and regional policies;

(4) performance metrics and risk management, highlighting climate change, machine learning, and explainable AI; (5) sustainability and corporate responsibility, centered on CSR, ESG investing, and transparency; (6) business practices and impact, linking ESG performance with firm success; (7) ethical considerations, stressing responsibility and stakeholder theory; and (8) technological challenges and opportunities, where blockchain, IoT, and big data drive but also complicate ESG reporting. Together, these clusters illustrate a complex, interconnected research landscape where technology, governance, and sustainability converge.

This study has several limitations. First, the analysis relied solely on the Web of Science database, which may exclude relevant studies from other sources. Second, bibliometric methods emphasize quantitative indicators such as citations and keyword co-occurrence, but do not capture the deeper qualitative insights of case studies or theoretical frameworks. Third, the dataset was limited to 2015–2025, and given the rapid evolution of blockchain, AI, and ESG policies, future research will need continuous updates to reflect emerging developments.

Future studies should expand to multiple databases, combine bibliometric and qualitative approaches, and explore practical barriers such as regulatory inconsistencies, ethical risks, and the environmental costs of digital technologies. Interdisciplinary and comparative research across regions and industries will be crucial to provide more holistic and actionable insights into how blockchain and AI can best support ESG objectives.

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