ISSN: 2658-8455
Volume 7, Issue 02 (2026), pp. 516-531.

Artificial intelligence in green finance: Insights from a PRISMA-driven bibliometric analysis in R

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Disclosure Statement :	The authors declare that they have not received any financial support that could have influenced the objectivity of this study. They take full responsibility for any potential plagiarism, the use of artificial intelligence in the writing process, as well as for the results presented in this article.
Conflict of Interest :	The authors report no conflicts of interest.
Acknowledgements:	The first author expresses sincere gratitude to the CNRST (National Center for Scientific and Technical Research) of Morocco for the award of the PASS scholarship associated with the doctoral program.
Cite this article :	YOUBI, D., & OUCHEN, A. (2026). Artificial intelligence in green finance: Insights from a PRISMA-driven bibliometric analysis in R. *International Journal of Accounting, Finance, Auditing, Management and Economics*, *7*(2), 516–531. https://doi.org/10.5281/zenodo.18457727
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Received: 04/01/2026 *Accepted: 08/02/2026*

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Abstract:

Sustainable finance has become an essential area of research as environmental and social challenges increasingly shape financial decision making. In this context, artificial intelligence (AI) has emerged as a catalyst for innovation and forecasting processes. However, its integration into sustainable finance, particularly in the context of green finance, is still not fully understood. This study examines how research at the intersection of artificial intelligence and sustainable finance, green finance had evolved over time through a bibliometric analysis of 301 publications indexed in Web of science and Scopus between 1986 and 2025, Using the bibliometrix package in R and following PRISMA guidelines, this study examines publication trends, influential contributors, emerging research themes, and additional bibliometric indicators, including co-authorship networks, citation patterns, and keyword co-occurrence analyses.. The results reveal a strong growth rate of 29,39% with approximately 99% of publications produced between 2021 and 2025, highlighting the highly emergent and rapidly evolving nature of this research field, with particular attention to ESG assessment, risk analysis, and green finance applications. China, India, the United Kingdom, Malaysia, and the United States lead scientific production. The analysis further reveals a strongly collaborative research landscape, structured around distinct international co-authorship networks dominated by Asian and Western research hubs. Influential journals such as Sustainability, Energy Economics, and the International Review of Financial Analysis play a central role in shaping academic discussions. These findings point to important implications for financial institutions and policymakers, showing that artificial intelligence has the potential to improve transparency, enhance the credibility of green finance practices, and support more informed sustainability-oriented decision making.

Keywords: Artificial Intelligence, Green Finance, Sustainable Finance, Bibliometric Analysis, PRISMA
Classification JEL: B41, Q56, O33
Paper type: Theoretical Research

Résumé:

La finance durable est devenue un domaine de recherche essentiel, car les défis environnementaux et sociaux influencent de plus en plus les décisions financières. Dans ce contexte, l'intelligence artificielle (IA) est apparue comme un catalyseur des processus d'innovation et de prévision. Cependant, son intégration dans la finance durable, en particulier dans le contexte de la finance verte, n'est pas encore pleinement comprise. Cette étude examine comment la recherche à l'intersection de l'intelligence artificielle et de la finance durable, la finance verte, a évolué au fil du temps grâce à une analyse bibliométrique de 301 publications indexées dans Web of science et Scopus entre 1986 et 2025. À l'aide du package bibliometrix dans R et en suivant les lignes directrices PRISMA, cette étude examine les tendances en matière de publication, les contributeurs influents, les thèmes de recherche émergents et d'autres indicateurs bibliométriques, notamment les réseaux de co-auteur, les modèles de citation et les analyses de cooccurrence de mots-clés. Les résultats révèlent un fort taux de croissance de 29,39 %, avec environ 99 % des publications produites entre 2021 et 2025, soulignant la nature très émergente et en rapide évolution de ce domaine de recherche, avec une attention particulière pour l'évaluation ESG, l'analyse des risques et les applications de la finance verte. La Chine, l'Inde, le Royaume-Uni, la Malaisie et les États-Unis sont en tête de la production scientifique. L'analyse révèle en outre un paysage de recherche fortement collaboratif, structuré autour de réseaux internationaux de co-auteur distincts, dominés par des pôles de recherche asiatiques et occidentaux. Des revues influentes telles que *Sustainability*, *Energy Economics* et *International Review of Financial Analysis* jouent un rôle central dans l'orientation des discussions académiques. Ces résultats ont des implications importantes pour les institutions financières et les décideurs politiques, car ils montrent que l'intelligence artificielle a le potentiel d'améliorer la transparence, de renforcer la crédibilité des pratiques de finance verte et de soutenir une prise de décision plus éclairée en matière de durabilité.

Mots clés : Intelligence artificielle, finance verte, finance durable, analyse bibliométrique, PRISMA
JEL Classification : B41, Q56, O33
Type du papier : Recherche Théorique

ISSN: 2658-8455
Volume 7, Issue 02 (2026), pp. 516-531.

1. Introduction

Climate change and environmental degradation pose growing threats to ecosystems, economies and societies worldwide. The growing risk of global temperatures exceeding the critical 2°C temperature threshold has intensified international efforts, notably through initiatives such as the 2015 Paris Agreement and the United Nations Sustainable Development Goals (Tsalis et al., 2020). In response**,** sustainable finance has become a central driver in guiding financial systems toward a low carbon transition. Rather than focusing solely on green investments, it presents a broader approach aims at strengthening financial resilience while supporting long-term environmental sustainability (Desai et al., 2022),with empirical studies indicating that ESG portfolios can be less volatile than conventional benchmarks (Ouchen, 2021).Driven by advances in computer science, robotics, machine learning, and data management, firms have progressively integrated increasingly sophisticated digital technologies into their business operations. Prior research shows that these technological developments have enhanced organizational capabilities, decision-making processes, and operational efficiency, while also requiring a sufficient level of firm-level readiness in terms of skills, infrastructure, and strategic alignment (Alsheibani et al., 2018; Dwivedi et al., 2021). Within this technological landscape, artificial intelligence has emerged as a key enabler, attracting growing attention across society, industry, and business due to its potential to transform managerial practices and improve firm performance, particularly through advanced data analytics and risk mitigation capabilities (Ho et al., 2022). In this perspective, the integration of artificial intelligence with big data offers new opportunities to enhance ESG assessments through advanced analytical models and intelligent data processing techniques (Li et al., 2024; Du & Chen, 2025). From a theoretical perspective, this literature is interpreted through stakeholder, institutional, and resource-based perspectives, which frame sustainability integration and artificial intelligence adoption as strategic and legitimacy-driven processes. Although research on sustainable finance and artificial intelligence is expanding rapidly, most existing bibliometric studies do not include publications from 2024 and 2025 years that represent a peak in research activity. Moreover, many of these studies rely on a single bibliographic database, which limits the breadth and robustness of their analyses. For instance, recent reviews by Roy and Vasa (2025) and Alqudah et al. (2025) are based exclusively on a single database, which limits the breadth of their analyses. This paper addresses these gaps by conducting a bibliometric analysis based on the Scopus and Web of Science databases, covering the period 1986–2025. The research design is guided by the PRISMA framework, which provides a transparent and systematic approach to identifying, screening, and selecting relevant studies, thereby enhancing the rigor, reproducibility, and reliability of literature-based analyses (Page et al., 2021). Through the examination of citation patterns, publication trends, and collaboration networks, bibliometric methods offer valuable insights for researchers, policymakers, and practitioners. The analysis traces the evolution of research on sustainable finance and artificial intelligence and identifies the key thematic clusters structuring the field. All analyses were conducted using the R programming language, relying on the *bibliometrix* and *biblioshiny* packages (Choudhri et al., 2015). To guide the scope and structure of this study, the following research questions are addressed: (1) How has research on sustainable finance and artificial intelligence evolved over time in terms of publication trends, and which countries, journals, and authors have played a central role in shaping this field? (2) What key thematic patterns emerge from the literature, and how do these themes reflect the evolving role of artificial intelligence within sustainable finance? This paper unfolds as follows: first, we provide a theoretical background elucidating the relationship between sustainable finance and AI. Next, we describe the methodology employed for conducting the bibliometric analysis. The subsequent section reports and discuss the main findings, followed by a discussion of the implications and limitations. Finally, the

paper concludes by outlining key insights and recommendations for future research in this evolving field.

2. Theoretical background

This section presents the conceptual background of sustainable finance, which constitutes the core of the present bibliometric analysis. The emergence of sustainable finance can be traced back to the mid-1980s, with early research focusing on social investment practices (Ferris & Rykaczewski, 1986). During the 1990s and 2000s, this line of research progressively expanded to incorporate broader dimensions related to socially responsible investment and environmental sustainability, reflecting growing concerns about the societal and ecological impacts of financial activities (Statman, 2000; Heinkel et al., 2001). More recently, particularly between 2020 and 2025, scholarly attention has increasingly shifted toward the role of emerging technologies, with artificial intelligence becoming a central element in discussions on sustainable finance. This shift reflects the growing interest in data-driven approaches and advanced analytical tools to address complex sustainability-related challenges in financial decision-making. Today, the finance and business sectors are widely recognized as key contributors to the advancement of sustainability objectives, alongside public institutions (Sætra, 2021). As a result, contemporary discussions on corporate social responsibility extend beyond traditional financial performance metrics, encompassing a broader set of social and environmental challenges that firms are expected to address (Verbin, 2020).

On the other hand, the origins of artificial intelligence can be traced back to the mathematical models of neural networks developed by McCulloch and Pitts (1943), which laid the theoretical foundations for machine-based reasoning. Artificial intelligence subsequently emerged as an independent field of scientific inquiry during the Dartmouth Conference, a milestone event that formalized AI as a distinct research domain (Lighthill, 1973). Foundational contributions by scholars such as Minsky and Shannon played a decisive role in shaping the early conceptual and methodological development of artificial intelligence, particularly with respect to problem-solving, information processing, and learning mechanisms.

Over time, AI has evolved into a transformative and pervasive technology, increasingly integrated across a wide range of sectors, including finance, where it is used for tasks such as data analysis, decision support, and risk management. At the same time, the growing diffusion of AI has raised important ethical, social, and governance-related debates concerning transparency, accountability, and societal impact (Moravec, 1988; Bostrom, 2014). More recently, companies have also come under increasing pressure from regulators, investors, and civil society to integrate sustainability principles into their financial and managerial practices, reflecting heightened expectations regarding corporate responsibility and long-term value creation (Benhayoun & Zejjari, 2022).

Although artificial intelligence and sustainable finance have each been the subject of extensive research streams when considered independently, their interactions remain relatively underexplored in the academic literature. This review seeks to address this gap by synthesizing existing research and offering a comprehensive understanding of the conceptual and thematic links between sustainable finance and artificial intelligence.

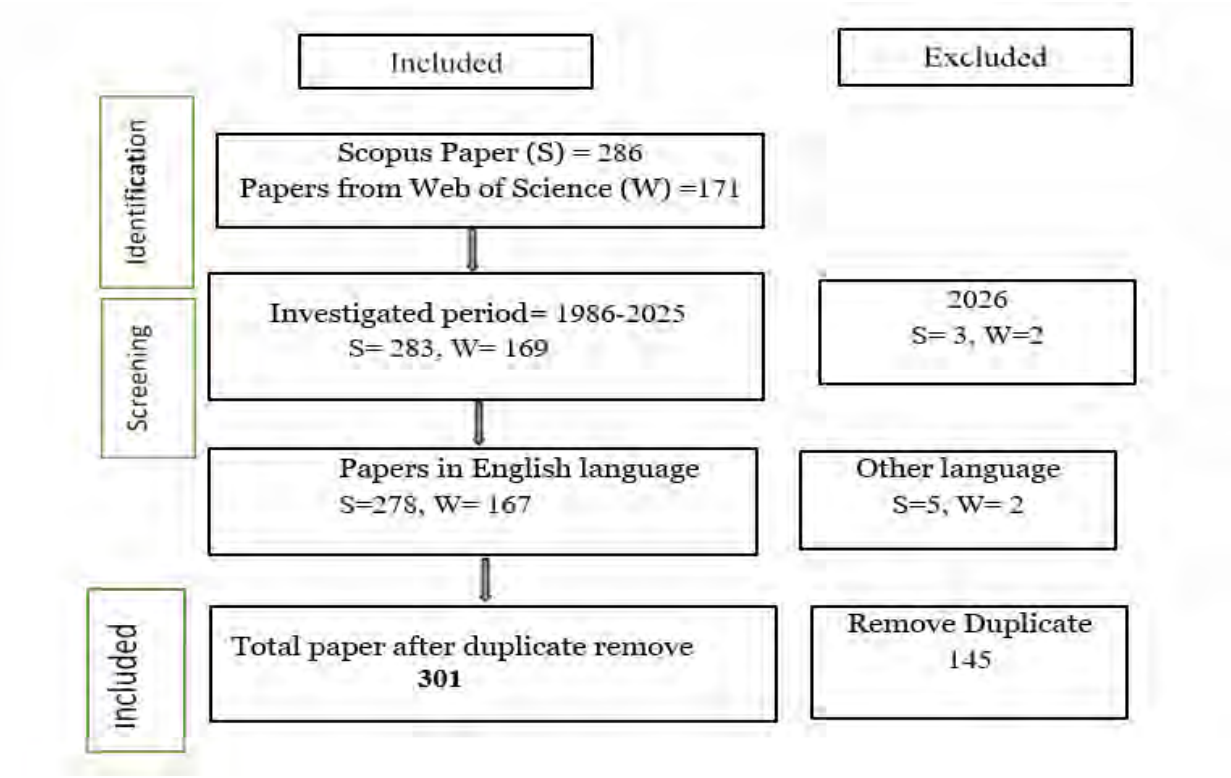
3. Methodology

This study adopts a bibliometric review design, rather than a traditional systematic review with meta-analysis. Accordingly, the objective is to map and structure the existing literature on artificial intelligence and sustainable finance, in line with a scoping-oriented bibliometric approach. In this context, the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) framework is used as a reporting framework to ensure transparency and

ISSN: 2658-8455
Volume 7, Issue 02 (2026), pp. 516-531.

traceability of the identification, screening, and inclusion of documents, and not as a guide for study quality assessment or effect-size synthesis, which are typical of clinical or experimental meta-analyses. This usage is consistent with PRISMA extensions such as PRISMA-ScR, which are adapted to literature mapping and scoping reviews (Page et al., 2021). The bibliometric analysis is carried out using bibliographic data retrieved from the Scopus and Web of Science databases on November 11, 2025. The search was conducted in document titles, abstracts, and keywords in Scopus, and across all fields in Web of Science, in order to ensure comprehensive coverage of the literature. This strategy reflects differences in database indexing structures, as Scopus does not provide a strict "all fields" search option; consequently, the TITLE-ABS-KEY query represents the broadest functional equivalent available in Scopus. Synonymous keywords were systematically harmonized, with particular attention to green finance–related terms, in order to limit ambiguity in the scope of the analysis. The search query was defined as follows: ("sustainabl* finance" OR "green finance" OR "ESG") combined with ("artificial intelligence" OR "AI"). The search was limited to English-language publications and excluded the year 2026, as the data collection was conducted before the completion of that publication year. No restrictions were applied with respect to document type or disciplinary domain; journal articles, review papers, conference proceedings, and all subject areas indexed in Scopus and Web of Science were included in the analysis. The documents were extracted from these databases, which are recognized as two of the most extensive and authoritative sources of scientific information worldwide, providing a solid foundation for bibliometric analysis (AlRyalat et al., 2019). Based on the defined query, a total of 457 documents were retrieved, including 286 from Scopus and 171 from Web of Science, and downloaded in tab-separated format to ensure a broad and inclusive overview of the literature. Duplicate records were identified and removed using the R programming environment, resulting in a final dataset of 301 unique publications (see Figure 1). The bibliometric analysis was conducted using the bibliometrix package and its Biblioshiny web interface in R, which enables the analysis and visualization of publication growth, authorship patterns, country collaboration networks, citation structures, and keyword co-occurrence networks (Aria & Cuccurullo, 2017).Specifically, the analyses included descriptive indicators (annual scientific production, most productive authors, journals, and countries), citation analyses (most cited documents and sources), and network analyses covering co-authorship networks, country collaboration networks, and keyword co-occurrence structures. The R programming language was selected for its flexibility and its wide range of tools for bibliometric research. Its capacity for data processing, visualization, and statistical analysis makes it an effective tool for examining complex bibliographic datasets and generating robust analytical insights (Choudhri et al., 2015). For network-based analyses, keyword co-occurrence and collaboration networks were constructed following standard bibliometric procedures implemented in the Bibliometrix/Biblioshiny environment, including frequency-based filtering of terms, association-based normalization, community-detection clustering, and keyword cleaning through the harmonization of synonymous expressions.

Figure 1:PRISMA Guided Screening and Inclusion Process



Source: Authors, based on PRISMA.

4. Results and Discussion

4.1. Data Overview

The final dataset comprises 301 publications published across 144 academic sources, highlighting the multidisciplinary and increasingly fragmented nature of research at the intersection of artificial intelligence and sustainable finance. The steady expansion of the field is reflected in an annual growth rate of 29.39%, calculated over the period 1986–2025 based on the compound annual growth of publications, while the document average age indicates the mean number of years since publication of the documents included in the dataset, reflecting the relative maturity of the literature. A total of 906 authors contributed to the dataset, reflecting a broad and diverse research community. Among them, 39 publications were written by single authors, suggesting that individual contributions remain present alongside collaborative efforts. Overall, however, research in this field is largely collaborative, with an average of 3.38 co-authors per publication. International collaboration is also notable, as 20,27% of the documents involve authors affiliated with institutions from multiple countries. From a methodological perspective, the literature draws on a diverse set of research designs, including literature reviews (Li et al., 2024; Nefla & Jellouli, 2025), quantitative analyses (Du & Chen, 2025; Kuang et al., 2024), qualitative studies (Sætra, 2021), and hybrid approaches combining multiple methods (Liu et al., 2024; Skapa et al., 2023). This methodological diversity reflects the variety of perspectives and analytical strategies employed to examine the various dimensions and applications of artificial intelligence within sustainable finance. (see Table 1).

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Table 1: Overview of the extracted papers

Description	Results
Main information about data	
Timespan	2005:2025
Sources (journals, books, etc.)	144
Documents	301
Annual growth rate %	29.39
Document average age	0.748
Average citations per doc	6.89
AUTHORS	
Authors	906
Authors of single-authored docs	39
AUTHORS COLLABORATION	
Single-authored docs	41
Co-Authors per Doc	3.38
International co-authorships %	20.27

Source: Authors' elaboration using Biblioshiny (R)

Although the search strategy initially covered publications from 1986 to 2025, bibliometric indicators related to publication dynamics were computed over the 2005–2025 period, corresponding to the phase of sustained scholarly output in the field

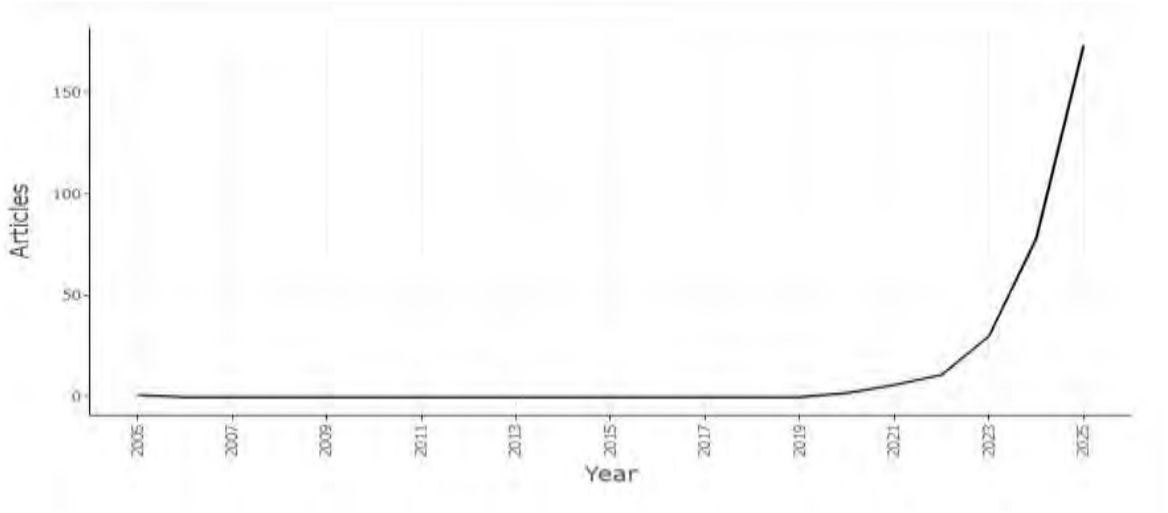
4.2. Publications and Citations trends

The dataset covers the period from 1986 to November 2025. Despite this extended time span, scientific output in this field is remarkably recent. A single isolated publication appears in 2005, followed by a complete absence of contributions until 2019. This long latency period suggests that the intersection between artificial intelligence and sustainable finance did not emerge as a distinct research domain until very recently. The year 2020 records only two documents, representing the very first signs of scholarly interest (see Figure 2), a timing that coincides with the acceleration of digital transformation in finance and the growing prominence of sustainability issues following major global disruptions, including the COVID-19 crisis.

The field begins to take shape in 2021, with six publications marking the onset of sustained academic engagement. This inflection point aligns with heightened regulatory attention to ESG issues, the rapid diffusion of AI-based financial technologies, and increased pressure on firms and financial institutions to integrate sustainability considerations into data-driven decision-making. From that point onward, growth becomes both rapid and continuous. The number of publications rose to 11 in 2022, representing an increase of 83%, before accelerating further to 30 articles in 2023 (+173%). This acceleration intensified in 2024, which recorded 78 publications, corresponding to a 160% increase. Although the data for 2025 remain incomplete, as they were collected in November, the year already accounts for 173 publications. This volume not only surpasses the cumulative output of all previous years but also represents 57.7% of the entire dataset. This reflects the consolidation of the field as a major area of scholarly inquiry. Such a trajectory clearly indicates a strong acceleration in research activity, signaling the entry of the field into a phase of rapid maturation.

Overall, 301 publications were identified between 2005 and November 2025, are overwhelmingly concentrated in the period from 2021 to 2025, which accounts for 298 publications, or 99% of the total output. This concentration confirms the highly emergent yet exceptionally dynamic nature of research at the intersection of artificial intelligence and sustainable finance. At the same time, it points to a potential time-window bias, as recent years naturally receive greater visibility in bibliometric analyses; therefore, observed growth rates and thematic prominence should be interpreted in light of the recency of the field and the rapid expansion of AI technologies and sustainable finance agendas during the last decade.

Figure 2: Publication trends



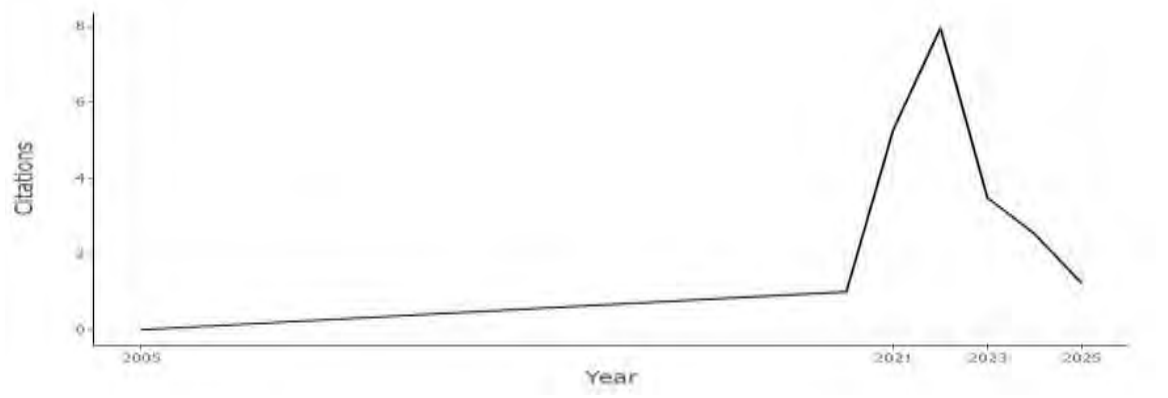
Source: Authors' elaboration using Biblioshiny (R)

Citation dynamics provide additional insight into the early-stage nature of the field (see Figure 3). The single publication recorded in 2005 received no citations, while the two articles published in 2020 achieved a modest average of 7.00 citations per article. Citation impact increased markedly thereafter, reaching 31.67 citations per article in 2021 and peaking at 39.82 in 2022, thereby positioning these early works as key reference points within the literature. These highly cited contributions can be interpreted as foundational studies, which helped structure subsequent research agendas and provided conceptual or methodological anchors for later publications.

From 2023 onward, the average number of citations per article declined to 13.90, 7.58, and 2.45 in 2023, 2024, and 2025, respectively. This pattern largely reflects the sharp rise in publication volume combined with the limited time available for more recent studies to accumulate citations. In addition, this citation concentration around early influential works may suggest the presence of a Matthew effect, whereby seminal contributions published during the formative phase of the field attract a disproportionate share of citations relative to more recent studies (Merton, 1968).

Despite this, the 301 publications identified between 2005 and November 2025 have collectively received 2,074 citations, highlighting the swift scholarly recognition of this emerging research domain. This dynamic further reflects the rapid consolidation of core intellectual references despite the recency of the literature.

***Figure* 3: *Citation* trends**



Source: Authors' elaboration using Biblioshiny (R)

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4.3. Author collaboration and performance

Table2 present the most important authors in the area of sustainable finance and artificial intelligence. Yushi Chen leads with 8 publications, 18 total citations and an H-index of 2 over 4 active years, combining both productivity and notable early impact. Khan M shows an academic trajectory with 5 publications accumulating 18 citations over a four-year period. By comparison, Li's scholarly output is more recent nut highly visible, with 4 publications produced within one year and a total of 15 citations, averaging 3.8 citations per article. Beyond the most prolific contributors, several authors have published between three and four articles within the dataset, including Li Y, Wang Q, Wang Y, Zhou X, Cao X, Chen J, and Dou J. These results indicate that this field is expanding rapidly, with productivity currently concentrated in China, highlighting opportunities for broader international contributions.

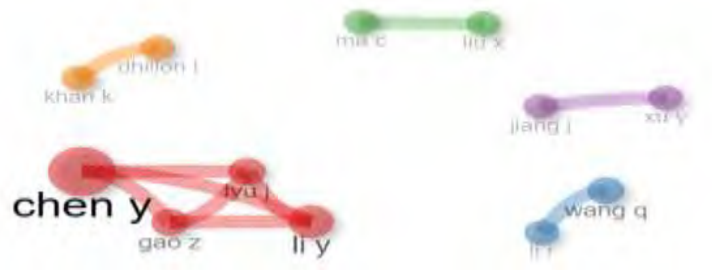
Table2: Top 10 authors according to number of publications.

Author	Articles	Articles Fractionalized
CHEN Y	8	2.87
KHAN M	5	1.13
LI X	4	1.42
LI Y	4	0.95
WANG Q	4	1.87
WANG Y	4	1.25
ZHOU X	4	0.84
CAO X	3	0.43
CHEN J	3	0.70
DOU J	3	0.83

Source: Authors' elaboration using Biblioshiny (R)

Figure 4 presents the co-authorship network in the sustainable finance-artificial intelligence domain, including authors with a minimum of two collaborative publications. The twelve authors are organized into five distinct clusters, Chen Y, Li Y, Gao Z, and Lyu J in the first cluster Wang Q and Li R in the second; Liu X and Ma C in the third; Xu Y and Jiang J in the fourth; and Dhillon L and Khan K in the fifth, reflecting the main collaborative groups within the field. Despite rising publication activity, the limited connections across clusters suggest substantial opportunities for further collaborative research and cross-regional collaboration.

Figure4: Collaboration among author



Source: Authors' elaboration using Biblioshiny (R)

4.4. Most influential papers and journals in the field

The highest-cited publication not only accumulates the highest number of citations but also exemplifies the evolution of research themes in the field (Taghizadeh-Hesary & Yoshino, 2019). Table 3 shows the most popular papers on sustainable finance and artificial intelligence published from 2021 onwards. All papers were published in recent years, indicative of a sharp

rise in scholarly attention to the sustainable finance- AI intersection. This rapid growth is largely attributable to the increasing adoption of AI to enhance financial decision-making and green economic efficiency (Kumar et al., 2025; Wang, 2025), growing requirement for high-quality ESG data and transparent reporting (Saxena et al., 2022; Sætra, 2021), as well as the accelerated digitization and sustainability agendas in the wake of major global shocks sus as COVID-19 pandemic (Debrah et al., 2023).

Table3. Most *influential* documents

Papers	Total Citations	TC per Year	Normalized TC
Kumar S, 2022, Annals of Operations Research	287	71.75	7.21
Wang Q, 2025, Human Soc Sci Commun	66	66.00	26.93
Saxena A, 2023, Sustainability	64	21.33	4.60
Saetra H, 2021, Sustainability	63	12.60	1.99
Debrah C, 2023, Clim Dev	60	20.00	4.32

Source: Authors' elaboration using Biblioshiny (R)

Table 4 lists the top five journals publishing at the intersection of sustainable finance and artificial intelligence. Sustainability ranks first with an H-index of 6, G-index of 12, 255 citations, and 12 articles since 2021.Energy Economics follows with H-index 5 G-index 7, and 122 citations despite starting in 2024, showing rapid attention to AI driven energy-finance topics. The International Review of Financial Analysis, Business Strategy and the Environment, and Journal of Environmental Management also demonstrate substantial impact, with H-indices between 3 and 5. Taken together these results demonstrate that research in sustainable finance and AI is rapidly across diverse interdisciplinary journals, with high-impact contributions emerging even from recent publications.

***Table* 4: *Top* 5 *popular* journal.**

Source	H-index	G-index	M-index	TC	NP	PY-start
Sustainability	6	12	1.200	255	12	2021
Energy Economics	5	7	2.500	122	7	2024
International Review of Financial Analysis	5	5	5.000	85	5	2025
Business Strategy and the Environment	3	3	3.000	21	3	2025
Journal of Environmental Management	3	3	3.000	14	4	2025

Source: Authors' elaboration using Biblioshiny (R)

4.5. Countries' Scientific Production Collaboration network

Figure 5 illustrates the global distribution of research at the intersection of sustainable finance and artificial intelligence. A strong concentration of publications is observed in Asia. Countries without publications are represented in grey, emphasizing the limited geographical coverage of the existing literature and revealing clear opportunities for future research in underrepresented regions. The predominance of Asian countries is consistent with previous studies indicating that the early adoption of green finance frameworks, together with substantial investment in artificial intelligence, has played a key role in shaping both policy and academic research in the region (Lee et al., 2022). This pattern is closely linked to proactive public policies in countries such as China and India, where national strategies explicitly promote artificial intelligence development and sustainable finance as complementary pillars of long-term economic transformation**.** In addition, the region faces pressing environmental and financial sustainability challenges, which have intensified academic and policy interest in AI-based solutions for sustainable finance. As a result, public policy priorities appear to strongly influence both the volume and thematic orientation of scholarly output in these countries.

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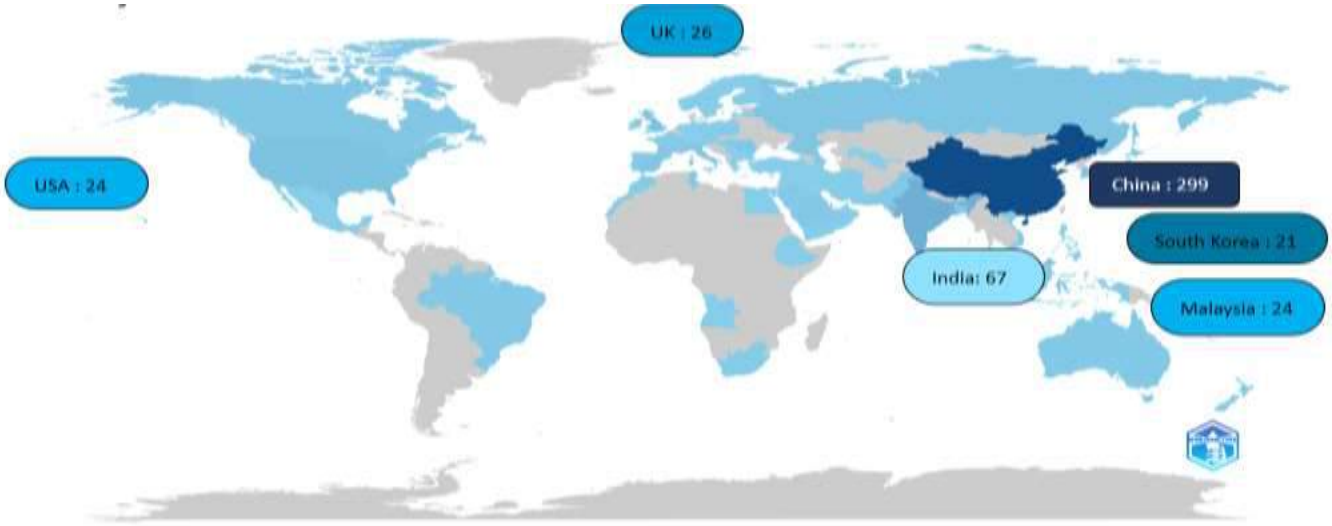
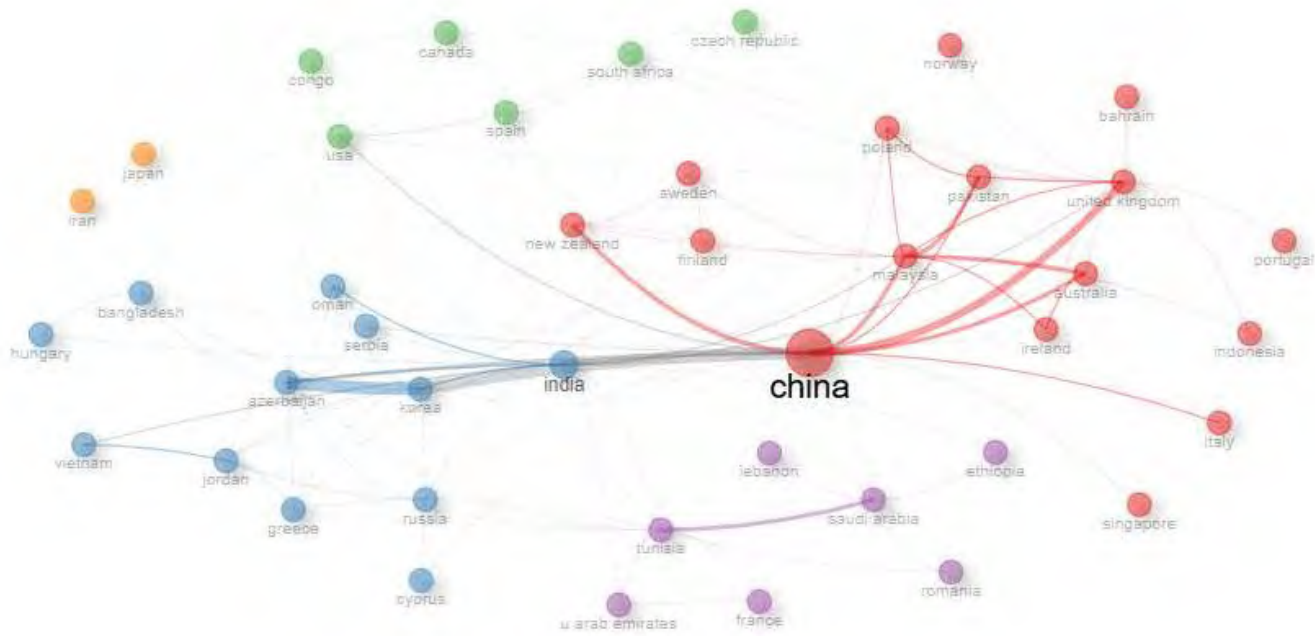
Figure5: Production map of countries.



Source: Authors' elaboration using Biblioshiny (R)

As illustrated in Figure 6, the international co-authorship network is filtered to include countries with at least two publications and two collaborative links. The analysis reveals five distinct collaboration clusters. China occupies a central position within the largest cluster, exhibiting extensive collaborative links with countries such as the United Kingdom, Malaysia, Pakistan, Australia, and several European nations. This prominent role is consistent with prior research showing that countries with strong research infrastructure and sustained investment in strategic fields tend to act as hubs within global research networks. China's centrality also reflects deliberate state-led policies aimed at international scientific cooperation and the global diffusion of AI-driven financial and sustainability innovations.

Figure 6*: *Collaboration* network *among* the *countries.



Source: Authors 'using Biblioshiny (R)

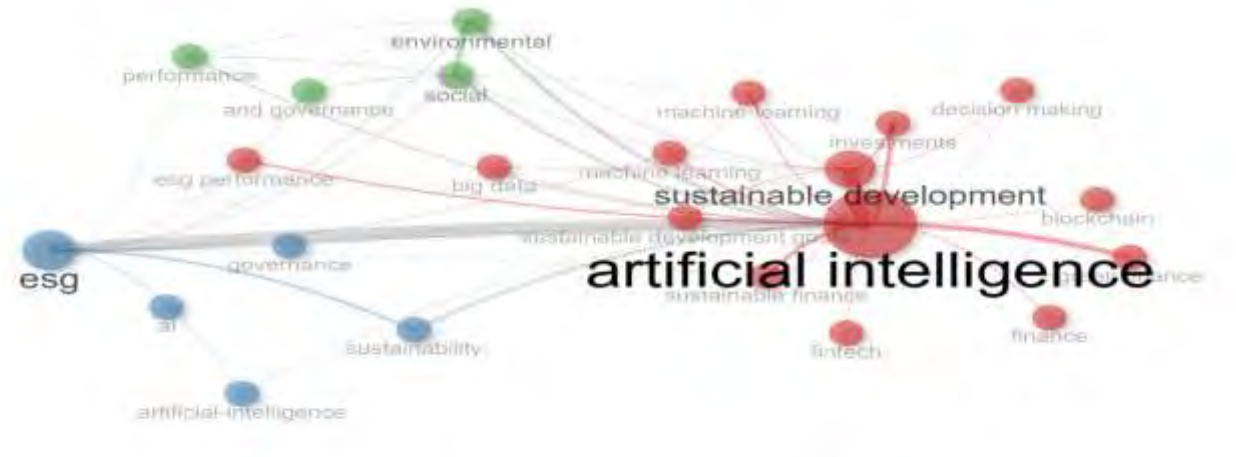
The second cluster is led by India and includes collaborations with countries such as Korea, Russia, Bangladesh, Vietnam, and neighboring countries. This pattern reflects the growing regional integration of research activities and the gradual strengthening of academic cooperation within Asia. It also mirrors India's policy emphasis on digital finance, fintech innovation, and sustainable development, which encourages cross-border academic and technological collaboration within the region. A third cluster, largely Western in orientation, is centered on the United States and includes Canada, Spain, South Africa, and the Czech Republic, forming an additional center of international collaboration.

Taken together, China and India emerge as key nodes within the global collaboration network. In contrast, several regions, particularly within the Global South, remain weakly integrated into international research collaborations. This pattern reflects structural constraints related to research funding, data availability, and institutional capacity (Kumar et al., 2022). It also suggests that the absence of coherent national strategies linking artificial intelligence and sustainable finance may limit both research output and international visibility in these regions, highlighting considerable opportunities to foster more inclusive and geographically diverse research partnerships.

4.6. Co-occurrence of keywords

Figure 7 illustrates the keyword co-occurrence network, which is organized into four distinct clusters. The network was constructed using author keywords appearing at least two times in the dataset, and keyword co-occurrences were normalized using an association-strength measure, while clusters were identified using a community-detection algorithm implemented in Bibliometrix. The first and most prominent cluster highlights the increasing role of artificial intelligence as a fundamental driver of sustainable finance. A second cluster highlights the increasing application of AI in evaluating corporate sustainability assessment and governance practices. The third cluster captures the core dimensions of the ESG framework and their direct connection to broader sustainability outcomes. The fourth cluster focuses on sustainability-oriented financial instruments and their contribution to global development goals. Overall, this network structure underscores the close integration of artificial intelligence with ESG and green finance themes, suggesting that digital innovation is increasingly regarded as a key driver of more sustainable and resilient financial systems.

Figure7: Co-occurrence of keywords



Source: Authors 'using Biblioshiny (R)

4.7. Future research agenda

To identify potential avenues for future research, trending topics were examined based on the

ISSN: 2658-8455
Volume 7, Issue 02 (2026), pp. 516-531.

most frequently cited keywords in the literature. The centrality of artificial intelligence, sustainable finance, ESG, and green finance indicates a clear shift toward sustainability frameworks increasingly supported by digital technologies, a pattern confirmed by their high frequency and central positioning in the keyword co-occurrence network. In addition, the repeated co-occurrence of machine learning, big data, blockchain, and fintech highlights the accelerating digitalization of sustainable finance practices, characterized by a growing reliance on data-intensive approaches for financial decision-making, as reflected in their strong clustering within the dominant technological themes identified in Figure 7.

Building on these trends, future research could further investigate how artificial intelligence contributes to improving the accuracy, transparency, and comparability of ESG assessments. This research avenue is supported by the high recurrence of ESG-related keywords combined with AI-related terms, yet the relatively limited differentiation of sub-themes related to measurement and standardization within the network. Such investigations are increasingly important given heightened concerns about greenwashing and the growing demand for more consistent and standardized sustainability reporting. Moreover, AI-driven models offer significant potential for enhancing climate-related financial decision making by improving risk prediction, optimizing resource allocation, and enabling more robust monitoring of corporate sustainability performance. This opportunity is consistent with the moderate but growing presence of keywords related to climate risk, risk management, and sustainability performance, which appear less central than core AI and ESG terms but indicate an emerging research frontier. At the same time, ethical, regulatory, and governance challenges related to the increasing use of artificial intelligence in sustainable finance remain limited scholarly attention. This gap is clearly observable in the bibliometric results through the low frequency or absence of keywords such as ethics, accountability, transparency, and algorithmic governance in the co-occurrence network. Future research is therefore needed to address concerns surrounding algorithmic bias, data governance frameworks, and the transparency of AI-based sustainability evaluation processes, areas that currently remain peripheral in the bibliometric structure of the field despite their growing policy relevance**.**

5. Conclusion

This paper aimed to enhance understanding of the relationship between artificial intelligence (AI) and sustainable finance by exploring the multidimensional dimensions that structure this rapidly expanding field of research. Based on a bibliometric analysis of 301 publications indexed in the Web of Science and Scopus databases, the study examines the structure, dynamics, and scientific evolution of research linking AI technologies with sustainable financial practices. The methodological approach relies on the bibliometrix package implemented in R, in accordance with the PRISMA guidelines. In response to the first research question: The results show a strong and rapid trends reveals a rapid expansion of research at the intersection of sustainable finance and artificial intelligence, as reflected by an annual growth rate of 29.39%. Nearly all publications (99%) were produced between 2021 and 2025, underscoring both the novelty and the accelerated development of this research area. China, India, the United Kingdom, Malaysia, and the United States appear as the leading contributors, and international collaboration is observed in 20.27% of the studies. Reflecting the increasingly global character of this research domain. Prominent journals, including Sustainability, Energy Economics, and the International Review of Financial Analysis have played a central role in disseminating this research, alongside influential contributions from authors including Chen Y, Khan M, and Li X. In response to the second research question: The thematic analysis indicated that the literature primarily focuses on AI applications in sustainable finance, ESG assessment, and green finance. Recent studies increasingly emphasize themes such as real time ESG data

processing, predictive risk assessment, and AI-driven sustainability innovations, pointing to the expanding role of artificial intelligence in shaping more efficient and sustainability focused financial practices. The findings of this study indicate that the artificial intelligence is increasingly emerging as a central driver of sustainable finance. The use of artificial intelligence for real-time ESG assessment, predictive risk analysis, and the optimization of green investment strategies, AI offers financial institutions and policymakers' valuable tools to enhance transparency, advance sustainability objectives, and stimulate innovation for both financial institutions and policymakers. Despite these contributions, this study has certain limitations. While relying on Web of Science and Scopus ensures data quality and consistency, the focus on English-language publications and the exclusion of grey literature may lead the omission of relevant research not indexed in these databases. Moreover, the analysis is purely bibliometric, without exploring qualitative aspects such as theoretical frameworks, methodologies, or practical applications. Future research could address these gaps through qualitative approaches, including content or thematic analyses, to gain deeper insights into emerging trends like AI-driven ESG assessment, predictive risk management and green finance.

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