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REIMAGINING AI-ENABLED DIGITAL GREEN FINANCE: AN APPRAISAL OF EMERGING THEMES AND RESEARCH FRONTLINES

GOURAV KAMBOJ[1] and Dr. SAKSHI BATHLA[2]

[1]Research Scholar, LM Thapar School of Management, Thapar Institute of Engineering and Technology (Deemed to be University), Patiala, Punjab, India. Email: gkamboj_phd25@thapar.edu
[2]Assistant Professor, LM Thapar School of Management, Thapar Institute of Engineering and Technology (Deemed to be University), Patiala, Punjab, India. Email: sakshi.bathla@thapar.edu

Abstract

The convergence of artificial intelligence, fintech and sustainable finance has augmented the transformation of global financial systems, yet the intellectual structure and thematic evolution of this emerging domain remain fragmented across disciplinary and jurisdictional boundaries. Addressing this gap, the present study integrates bibliometric analysis with systematic literature review techniques to synthesize the rapidly expanding scholarship on AI-enabled digital green finance published during 2020-2025. Drawing upon 341 Scopus-indexed articles for bibliometric mapping and 80 rigorously screened studies for thematic synthesis, this study employs Biblioshiny and VOSviewer to examine publication trends, influential authors, countries, collaborative networks, co-citation structures and thematic trajectories. The analysis identifies five dominant research clusters (a) AI-driven ESG analytics and sustainability reporting, (b) blockchain-enabled transparency mechanisms, (c) green fintech and financial inclusion, (d) AI-based climate-risk and sustainable investment systems and governance, (e) ethics and algorithmic accountability in digital green finance. The findings indicate a sharp expansion of the domain post-2020, driven primarily by sustainability-transition agendas, fintech innovation and data-centric ESG governance. Despite this growth, substantial gaps persist regarding explainable AI, longitudinal causal evidence, institutional heterogeneity and inclusive green-finance ecosystems. By integrating science mapping with thematic synthesis, the study contributes to a consolidated intellectual framework and future research agenda while offering policy and managerial insights for sustainable digital-finance governance.

Keywords: Digital Green Finance, Artificial Intelligence, Sustainable Finance, Fintech, ESG, Bibliometric Analysis, Systematic Literature Review, Climate Finance.

1. INTRODUCTION

The importance of financial systems in withstanding the Sustainable Development Goals and low carbon economic transition in the context of accelerating climate change and environmental degradation has undergone profound changes. Green and sustainable finance have become important advances to redirect capital investment to green investments, renewable energy projects, climate adaptation measures and ESG-related business models in the past decade (G. Zhou et al., 2022). Concurrently, the financial ecosystem has experienced a dramatic transformation across the globe brought about by the rapid development of AI, machine learning, blockchain, big data and fintech innovations (Y. Yang et al., 2021).

Over the past few years, the use of AI-powered sustainability systems in financial markets has been on the rise like never before. Similarly, the application of AI technologies for sustainability reporting, climate-risk modelling, Environmental Social & Governance analytics and the allocation of green-credit and sustainable investment optimization (A. H. Huang et al., 2023) has increased the interest of financial institutions, investors, regulators, and ESG-rating agencies in adopting AI technologies.

After the pandemic, apart from many other disruptions, digital transformation has accelerated, ESG disclosure requirements are increasing, companies are committing to becoming carbon neutral and investors are increasingly seeking sustainable assets, all of which have contributed to the rapid expansion of sustainable finance through AI post-2020 (Roy & Vasa, 2025). This

evolution is reflected in the number of academic publications, notably the ones that examine the intersection of AI, fintech, ESG systems, climate financing and sustainable investment mechanisms. Based on the literature, digital financial technologies have been proven impactful for environmental performance, green innovation financial and sustainable economic development, etc (W. Wang et al., 2025).

Despite this recent research, there is a conceptual disintegration and methodological dispersion in literature. Past research considered relative segments of the larger digital sustainability ecosystem - AI, fintech, blockchain, ESG, climate finance and green finance separately rather than as interconnected parts of a whole (Fotova Čiković et al., 2025). Moreover, most of the previous reviews concentrate on bibliometric mapping or conceptual synthesis individually and a comparatively smaller number of studies combined the science mapping methods with systematic thematic analysis. This reflects the lack of theoretical groundwork and future research directions of digital green finance in the field of artificial intelligence. Another limitation directs towards the geographical focus of the extant literature. Empirical evidence largely originates from China and a select number of other Asian economies, as they have an increasingly large digital-finance sector and policy experimentation in the green-finance sphere (G. Zhou et al., 2022). These settings provide good context but not necessarily provide a broad applicability of findings in institutional and regulatory settings.

Given the above-mentioned constraints, there is a need to review the living literature in a comprehensive and systematic way. In the context of the application of AI in digital green finance research, the use of the hybrid method of bibliometric and systematic literature review is therefore adopted as the main approach used in this study. By integrating, Biblioshiny and VOSviewer based science mapping with thematic content analysis. The study identifies publications trends, influential journals, thematic clusters and future research directions in the area.

Moreover, there are several important contributions of this study: first, it is one of the very few integrated hybrid reviews which examines the interplay of all these things, including AI, fintech, blockchain, ESG systems and green finance. Second, the concepts and subject focus are identified in the field through bibliometric network analysis. Thirdly, it combines the theoretical and methodological frameworks used in current research. Finally, the review provides an agenda for future research on novel challenges in the field of explainable AI, governance quality, algorithmic accountability and sustainable digital finance ecosystems. To achieve these objectives, the study addresses the following research questions:

RQ1. How has the research in AI-enabled digital green finance evolved in terms of publications and research interest during 2020–2025?

RQ2. Which journals, authors, countries, documents and keywords have contributed the most in developing this field of research?

RQ3. Which dominant thematic clusters and intellectual structures are embodied in AI-enabled digital green finance research?

RQ4. Which theoretical frameworks, methodological approaches, and application areas govern the existing literature?

RQ5. What key research gaps and future research directions are crucial in advancing AI-enabled digital green finance scholarship?

2. SYNTHESES OF EXISTING REVIEW STUDIES

The existing reviews highlights the growing scholarly attention towards the intersection of artificial intelligence, fintech, ESG systems, blockchain and sustainable finance. The focal of these reviews revolved around fintech and sustainable development (Y. Yang et al., 2021), sustainable entrepreneurship and fintech ecosystems (Mansouri & Momtaz, 2022), AI technologies for ESG disclosure systems (A. H. Huang et al., 2023), and blockchain for green finance governance (M. Qin et al., 2023). In contemporary times, these literature reviews have combined bibliometric and systematic review to synthesize all probable insights on the subject. So far, these reviews are rather fragmented and scattered across technological, governance and sustainability aspects and dedicated to isolated aspects while neglecting the overall digital green-finance ecosystem (Macchiavello & Siri, 2022). Additionally, there is limited integration of bibliometric science mapping with in-depth thematic synthesis. There are fewer studies that examine under-researched areas like explainable AI, algorithmic governance, ESG and cross-country dynamics of sustainability finance. Thus, the present study offers a systematic review of the intellectual structure, thematic development and future research directions of AI powered digital green finance. It aims to overcome shortcomings by integrating bibliometric analysis and systematic thematic analysis that extends a comprehensive future perspective of the field.

Table 1: Prominent Reviews on AI-Enabled Digital Green Finance and Sustainable Financial Systems

Author(s) & Year	Title	Source Title	Review Type	Timeframe Covered	Databases Used	Research Gap areas Identified
(Y. Yang et al., 2021)	Nexus between green finance, fintech, and high-quality economic development	Resources Policy	Empirical quantitative study	2000–2020	Scopus	Role of fintech in sustainable economic transformation & green finance efficiency
(Mansouri & Momtaz, 2022)	FinTech and sustainable entrepreneurship	Journal of Business Venturing	Conceptual Review	2010–2021	Scopus	Ethical AI adoption, sustainability governance, and fintech-driven inclusion mechanisms
(A. H. Huang et al., 2023)	Artificial intelligence and ESG disclosure quality	Contemporary Accounting Research	Review-oriented Empirical Analysis	2015–2022	Scopus & Web of Science	AI explainability, ESG-data reliability, and governance implications in sustainable finance systems.
(M. Qin et al., 2023)	Blockchain, green finance, and carbon neutrality transition	Energy Economics	Review	2010–2022	Scopus	Integrated examination of blockchain transparency, climate finance, and ESG governance systems.
(Roy & Vasa, 2025)	Artificial intelligence and sustainable finance: A bibliometric and systematic literature review	Finance Research Letters	Hybrid Review (SLR +Bibliometric)	2015–2024	Scopus	Fragmented research across AI, ESG, fintech, and sustainable-finance streams; Insufficient theoretical integration and future-oriented synthesis.

3. LITERATURE REVIEW

3.1 Evolution of Digital Green Finance

Green finance has become a cutting-edge tool that connects hard-core finance with sustainable development and climate resilience and low-carbon economic transition. Traditionally, green finance was limited to green investment, green bonds and sustainable banking systems to mitigate environmental damage and to support climate-related goals (G. Zhou et al., 2022). The current digitalization of financial systems has given rise to a new generation of green finance. Digital green finance features data-based financial intermediation, fintech innovation and technology-based sustainability governance (Y. Yang et al., 2021).

The recent literature indicates how digital green finance participates in the financial technology, sustainability goals and governance mechanisms by enhancing transparency and enabling sustainable investment decisions (Macchiavello & Siri, 2022). This shift was accelerated in 2020 with the rise in the demand for ESG disclosures attributed to the rising climate risk. Since pandemic, digitalization has driven transformations and contributed to the accelerated use of AI for financial analytics for decision-making (Roy & Vasa, 2025).

3.2 Artificial Intelligence and Sustainable Financial Systems

AI is one of the most impactful technological forces transforming the modern financial systems. Machine learning, natural language processing, predictive analytics and large language models are now playing a more prominent role in the assessment of ESG factors, sustainability risks, climate forecasting, and optimization of green investment (Portillo-Tarragona et al., 2025).

AI-enabled financial systems enhance decision-making efficiency by enabling the analysis of massive environmental, financial and non-financial data in real time (Chandel & Arora, 2025). AI contributes to ESG analytics through automation of sustainability reporting, identification of greenwashing risks, and mitigation of information asymmetry between companies and investors (X. Ren et al., 2023). AI therefore is not just a tool but a strategic solution that can transform sustainable financial governance and environmental-risk management practices (Ali et al., 2025).

3.3 Blockchain, Fintech and Transparency in Green Finance

Another significant body of literature concerns blockchain and technological innovations for digital green finance. Blockchain has been progressively discussed as a tool to support the governance of sustainability, promote transparency and accountability in green financial ecosystems (Jangid et al., 2025). Its decentralized ledger technology ensures secure verification of sustainability-related transactions, carbon credits, and ESG disclosures, mitigating greenwashing and enhancing investor confidence.

Likewise, fintech systems like digital payments, Peer-to-Peer (P2P) lending and mobile financial services gradually facilitate the green economic transformation and sustainable financial inclusion(Mamun & László, 2025) .

Empirical studies have revealed that fintech innovation brings positive impacts on green growth, carbon-efficiency improvement and sustainable industrial development, especially in emerging economies (Z. Zhou et al., 2024). However, there is still a lack of consensus in the literature on institutional and regulatory issues related to blockchain-based sustainable finance systems (Metawa et al., 2022).

3.4 ESG Analytics and Sustainable Investment

ESG principles have recently become a part of investment decisions, thus placing digital technologies at the center of sustainable finance. A growing body of literature demonstrates the benefits of AI-driven ESG systems to accurately assess sustainability measures, improve forecasting of climate risks and enhanced optimization of a sustainable portfolio (Mirza et al., 2023; W. Wang et al., 2025) claimed that machine-learning algorithms are superior to traditional econometric models in their ability to detect financial risks and trends arising from environmental, social and governance factors.

AI-powered analytics are widely adopted by institutional investors for assessing green-investment opportunities and tracking environmental performance. (Elhady & Shohieb, 2025) indicated that the implementation of digital ESG systems can promote better corporate sustainability performance by fostering transparency, enhancing disclosure quality and enhancing stakeholder accountability. However there is still a lack of consistency in ESG measurement frameworks between different regions and institutions, marking a challenge in data comparability, reliability and standardization of governance (Ribeiro, 2024)

3.5 Theoretical Foundations of AI-enabled Digital Green Finance

The existing literature on digital green finance and AI is based on the stakeholders' theory, the institutional theory, resource-based view theory, information asymmetry theory, and the technology acceptance model (Brusseau, 2023; S. Feng et al., 2024). The stakeholders' theory is the response to ESG and sustainability concerns of businesses. It explains how companies implement ESG and relevant sustainability measures to meet the stakeholders' expectations and enhance the legitimacy of the business (Freeman, 1984).

Institutional Theory proposed by DiMaggio & Powell (1983) focuses on the importance of regulatory pressure, social norms and governance frameworks to create sustainable financial transformation. Barney (1991) used RBV theory to describe the sustainable competitive advantage and organizational resilience that can be generated with suitable AI capabilities in place, fintech infrastructure and digital innovation. Likewise, Information Asymmetry Theory (Akerlof, 1970). extensively utilises the contribution and role of AI and blockchain systems to enhance transparency (Aassouli et al., 2025; Rapach et al., 2024).

3.6 Key Research Findings and Evidence Base

The extant literature shows that AI-based digital finance positively affects ESG performance, the quality of sustainability reporting and financial decision-making addressing climate change (X. Ren et al., 2023). Multiple studies have shown that AI-powered ESG analytics enhance the accuracy of investment screening and boost the ability to predict climate risks by processing environmental and financial data in real time (W. Wang et al., 2025). Likewise, fintech innovation is strongly linked with green economic growth and sustainable financial inclusion (G. Zhou et al., 2022).

Empirical evidence indicates that digital finance contributes to green industrial transition and promotes green investment practices. The increased usage of blockchain enhances transparency and mitigates greenwashing risks in sustainable finance markets (M. Qin et al., 2023). Moreover, blockchain-based systems improve ESG verification, carbon-credit traceability and climate-finance accountability (Khalegi et al., 2024). However, there is a lack of evidence on challenges surrounding AI opacity, algorithmic bias, ESG-data inconsistency and governance quality (Astuti et al., 2025).

3.7 Research gaps and rationale for present synthesis

While the literature on AI-supported digital green finance has grown significantly, there is a need for a hybrid bibliometric and systematic review to address the gaps. First, there is a conceptual disconnection between research fields, as research on AI, fintech, ESG, blockchain, climate finance, and sustainability is largely evolve in isolation. It lacks integration with a larger digital sustainability research ecosystem (Fotova Čiković et al., 2025), which inhibits the cumulative theory development and decreases the coherence of a developing field.

Secondly, most of the existing reviews on the subject focused either on the narrative synthesis or bibliometric mapping, while fewer studies combined both science mapping and in-depth thematic analysis. Consequently, the intellectual organization, thematic development, methodological variety and theoretical underpinnings of the field remains under-researched (M. Yang et al., 2025).

Thirdly, the published research is still largely specific to a few institutions and settings (mainly China) and thus does not necessarily extend to other countries(Astuti et al., 2025). Finally, although certain emerging themes like explainable AI, algorithmic governance, ESG and decentralized green-finance ecosystems are now becoming more relevant in practice, they are not sufficiently explored theoretically(Zhu & Zhou, 2025).

These limitations, thus, direct towards the need for the methodological application of a hybrid bibliometric and systematic literature review. Such an approach is suitable for highly dynamic interdisciplinary fields with high publication rates and conceptual disintegration (Pandey, 2025).

4. DATA AND METHODOLOGY

4.1 Research design and review protocol

The present study employs a hybrid review design. It combines the bibliometric analysis and systematic literature review processes. It also provides a mapping of intellectual structure and thematic developments of digital green finance research in the context of AI. Such a design is suitable for the development of new interdisciplinary fields.

Wherein, the objectivity of bibliometric mapping blends with the in-depth qualitative synthesis for building theory and identification of future research areas. This approach has also been applied in recent review studies in green finance, fintech and blockchain enabled ESG, as well as AI enabled sustainable finance to ensure methodological rigor and conceptual completeness (Manta et al., 2025).

The present review is carried out employing a structured screening protocol reported in line with PRISMA to ensure transparency, replicability and academic integrity. This approach is based on recent review papers published in various high quality peer reviewed journals for systematic article selection, transparent inclusion/exclusion criteria, and documented screening decisions (Jangid et al., 2025; Nguyen, 2025).

4.2 Database selection and search strategy

For the present study, a hybrid approach combining bibliometric analysis and an SLR method has been employed. A search was conducted in May 2026 using Scopus database as it is widely used for its highly selective coverage for peer-reviewed business, economics, finance, sustainability and technology journals.

Identification: In the initial search, we used the following keywords: TITLE-ABS-KEY (("Artificial Intelligence" OR AI OR "Machine Learning" OR "Deep Learning" OR "Neural Networks" OR "Generative AI" OR FinTech) AND ("Digital Green Finance" OR "Green Finance" OR "Sustainable Finance" OR "Climate Finance" OR "Green FinTech" OR "ESG Finance" OR "Carbon Finance")). This string produced 1588 records on the Scopus database. The initial keywords were developed to ensure that the review encompasses the entire spectrum of recent literature over the development of sustainable finance and green-finance digitisation using AI.

Screening: These records were further refined using predefined filters on: (a) subject areas: "Economics, Econometrics and Finance" AND "Business, Management and Accounting", (b) Document types: Article; (c) Language: English; and lastly (d) Source type: Journal. The final number of articles thus reached 341 for the purpose of bibliometric analysis. The oldest and the newest article from this dataset was published in 2020 and 2025 respectively. The 2020-2025 window is thus warranted as the convergence of AI, fintech, ESG and digital green finance has picked up significantly since 2020, as a result of the digitalisation of the world due to the Covid-19 pandemic, the ESG disclosure pressure, the use of AI-powered climate-risk analytics, and the sustainability transition writ large (A. H. Huang et al., 2023). Hence, the final search string used for the database was: TITLE-ABS-KEY (("Artificial Intelligence" OR AI OR "Machine Learning" OR "Deep Learning" OR "Neural Networks" OR "Generative AI" OR FinTech) AND ("Digital Green Finance" OR "Green Finance" OR "Sustainable Finance" OR "Climate Finance" OR "Green FinTech" OR "ESG Finance" OR "Carbon Finance")) AND (LIMIT-TO (SUBJAREA , "ECON") OR LIMIT-TO (SUBJAREA , "BUSI")) AND (LIMIT-TO (DOCTYPE , "ar")) AND (LIMIT-TO (LANGUAGE , "English")) AND (LIMIT-TO (SRCTYPE , "j")). To evaluate the direct relevance of these records to the theme of AI, digital finance, ESG and green finance, they were manually screened using the titles, abstracts, and keywords. Further articles were dropped from the count when they were not technically oriented but had no clear relationship to finances/sustainability, were not within the business/economics field or were only tangential to the study topic. This step helped to achieve conceptual consistency and refine the final corpus. Out of 341 articles, 235 records excluded manually, 26 reports were not retrieved and the remaining records were discarded due to topic mismatch, no green finance or ESG content or engineering-technical orientation, at final stage 80 articles were retained for detailed SLR and thematic content analysis. The full-text review was conducted to ensure that each paper contributed to one or more of the themes under focus, including AI-driven ESG analytics, blockchain transparency, green fintech inclusion, climate-risk analytics, and governance and ethical accountability. Moreover, these studies were retained due to their conceptual, empirical, or methodological relevance to AI-powered digital green finance and their potential for further synthesizing themes, theories, methods and future directions of research.

In hybrid studies, the bibliometric set is generalised to map various themes whereas the SLR is selective to aid deep interpretation of those themes. So this dataset of 80 articles was finally used to achieve the analytical depth needed to enable you to identify dominant themes, theoretical lenses, methodological trends, and future research gaps with it. The method is aligned with recent review works in the areas of sustainability research with Artificial Intelligence (Nguyen, 2025), Blockchain-based finance (Jangid et al., 2025), and Green finance (Fotova Čiković et al., 2025). These studies have used a wide range of bibliometric sources and focused their selection of qualitative reviews for synthesis.

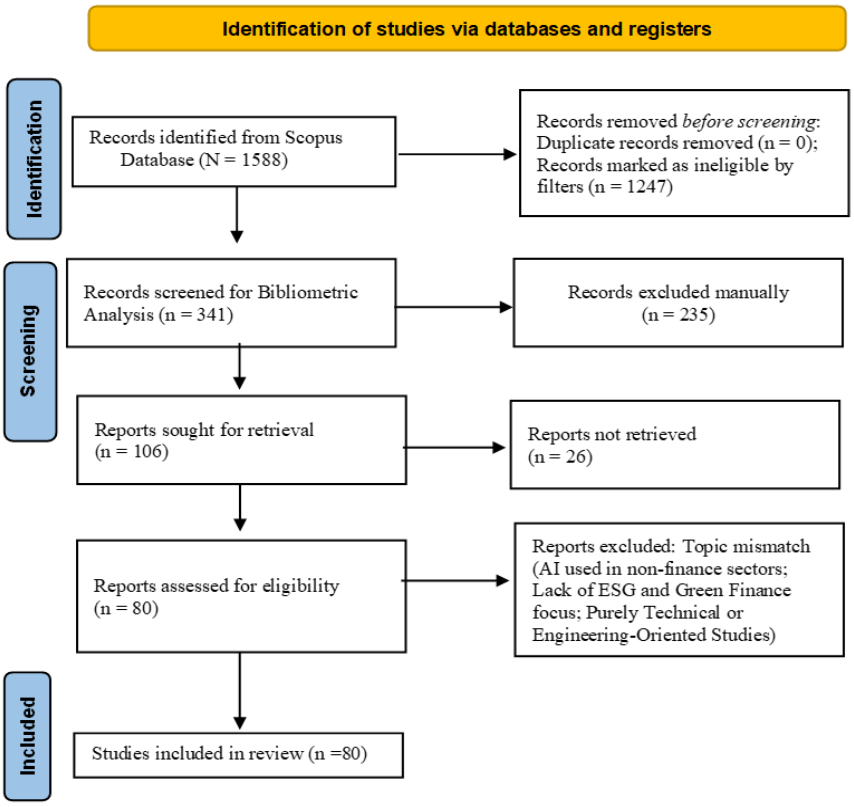

Fig 1: PRISMA diagram

5. FINDINGS

5.1 Descriptives of the data

These 341 journal articles were published in 154 sources, in total 1,017 authors contributed to the field, the final bibliometric corpus was published between 2020 and 2025. The dataset demonstrates an annual growth rate of 147.83% indicating high dynamism phase in the domain as shown in Table 2. The average citations per document is 25.06 which indicates that the domain is not only contemporary but has some scholarly relevance as well. Moreover, the descriptives regarding collaboration structure are interesting. It shows that there are 3.21 co-authors per document and 39% of them are international co-authors highlighting the interdisciplinarity as well as the research interest of international scholars in the field. To illustrate, recent review studies proposed that AI, fintech, ESG and sustainable finance are gradually merging into a single integrated research stream (Bawack et al., 2026; Tian et al., 2025).

Table 2: Descriptives of the data

Description	Results	Description	Results
MAIN INFORMATION ABOUT DATA		**AUTHORS**	
Timespan	2020:2025	Authors	1017
Sources (Journals, Books, etc)	154	Authors of single-authored docs	38
Documents	341	**AUTHORS COLLABORATION**	
Annual Growth Rate %	147.83	Single-authored docs	41
Document Average Age	1.69	Co-Authors per Doc	3.21
Average citations per doc	25.06	International co-authorships %	39
References	21911	**DOCUMENT TYPES**	

DOCUMENT CONTENTS		article	341
Keywords Plus (ID)	943		
Author's Keywords (DE)	948		

5.2 Annual publication trends

The rising trend in the number of publications per year is observed particularly after 2022, with the sharpest increase in 2024–2025 indicating a shift of research in AI-enabled financial industry from an early stage to a rapidly expanding one (see Fig 3 below). This shift is buoyed by digitalization following the pandemic, pressure to produce ESG reports, climate-risk analysis, and broader acceptance of the potential of AI in financial decision-making (Huang et al., 2023). In other words, the trend is a good sign of a timely, policy-relevant and intellectually stimulating topic for a review paper. Another important point about the curve is that the major growth of the field is definitely in the time window you have chosen (2020-2025), and that makes your time window methodologically correct (Mirza et al., 2023; Widiastuti et al., 2025).

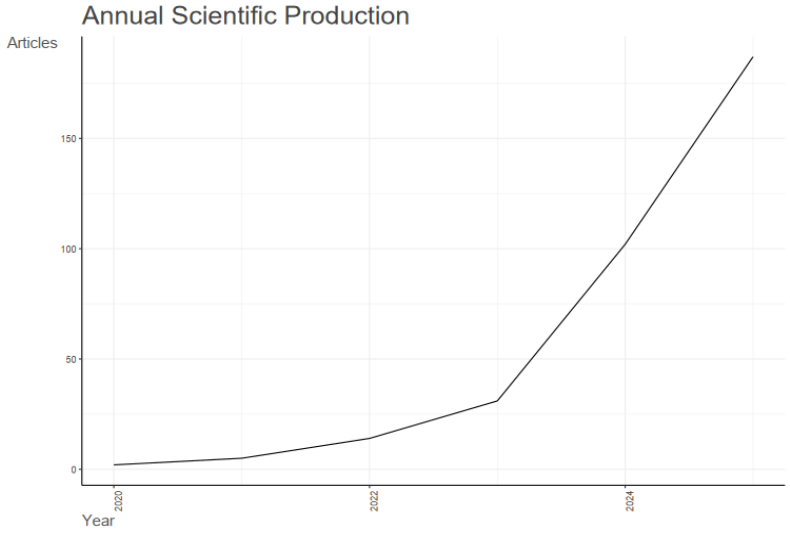

Fig 2: Annual Scientific Production

5.3 Most relevant journals

The source analysis indicates that amongst the top 10 journals, the Resources Policy is the most prominent publishing the highest number of articles in the domain, followed by the Finance Research Letters and Energy Economics (refer Table 3). This distribution is significant as it shows that the literature exists in the overlapping space of finance, sustainability, innovation and environmental economics, rather than being confined to a single disciplinary perspective(M. Sethi et al., 2025; Tiwari et al., 2025).

Table 3: Most Relevant Journals

Sources	Articles
RESOURCES POLICY	37
FINANCE RESEARCH LETTERS	23
ENERGY ECONOMICS	12
JOURNAL OF CLEANER PRODUCTION	12
HUMANITIES AND SOCIAL SCIENCES COMMUNICATIONS	11
INTERNATIONAL REVIEW OF FINANCIAL ANALYSIS	9
RESEARCH IN INTERNATIONAL BUSINESS AND FINANCE	9
JOURNAL OF RISK AND FINANCIAL MANAGEMENT	7
SUSTAINABLE FUTURES	7
ENVIRONMENT, DEVELOPMENT AND SUSTAINABILITY	6

5.4 Most relevant authors

The author analysis identifies Wang Y. and Wang J. as the most influential contributors in the dataset, with Wang H. standing out for the highest citation impact. Other prominent authors include Zhang Y., Chen H., Li X., and Wang Q. as shown in Table 4. This concentration of influence indicates that the field is still being shaped by a relatively small core of highly productive scholars, especially from East Asian research networks. Such concentration is typical in fast-growing domains, where a few influential research groups often define the early intellectual structure before broader international diffusion occurs(Bawack et al., 2026; Kiss et al., 2025).

Table 4: Most Relevant Authors

Authors' Name	h-index	g-index	m-index	TC (Total Citations)	NP (No. of Papers)
Wang Y.	7	10	2.333	147	10
Wang J.	7	8	1.400	144	8
Zhang Y.	4	7	1.000	78	7
Wang H.	4	5	1.000	516	5
Chen H.	4	5	0.800	86	5
Liu L.	4	4	1.000	58	4
Liu B.	4	4	1.333	55	4
Li X.	3	5	1.000	61	5
Wang Q.	3	4	0.750	195	4
Wang C.	3	4	1.000	41	4

5.5 Most cited countries

China by far is the dominant contributor, followed by India and Italy. Chinese leadership reflects both strong policy momentum in green finance and active research on digital finance and sustainability. Table 5 shows the top 10 contexts with most cited research works in the domain. The growing presence of India and other emerging economies suggests that the literature is not biased towards the Western markets, rather increasingly becoming relevant for the Global South. This finding supports a future research agenda advocating for empirical evidence, regulatory diversity, and financial inclusion in AI-enabled sustainable finance from developing-country (Nefla & Jellouli, 2025; J. Zhang & Sun, 2025).

Table 5: Most Cited Countries

Region	Freq	Region	Freq
CHINA	351	SAUDI ARABIA	31
INDIA	61	USA	29
ITALY	44	PAKISTAN	25
UK	37	AUSTRALIA	20
MALAYSIA	36	TURKEY	20

5.6 Most Global Cited Documents Analysis

The global citation analysis identifies foundational studies that are shaping the intellectual structure of AI-enabled digital green finance research. Highly cited contributions by (A. H. Huang et al., 2023; Y. Yang et al., 2021; G. Zhou et al., 2022) demonstrated the essence of green finance, fintech innovation, ESG analytics, and sustainable economic development within the field (see Fig 4). The citation impact of these studies strongly reflects their theoretical relevance and methodological influence in advancing digital sustainability-finance discourse. Additionally, the dominance of journals such as Ecological Economics, Contemporary Accounting Research and Resources Policy highlights the interdisciplinary integration of finance, sustainability, environmental economics, and technology studies (W.

Feng et al., 2025; Hassan et al., 2020).

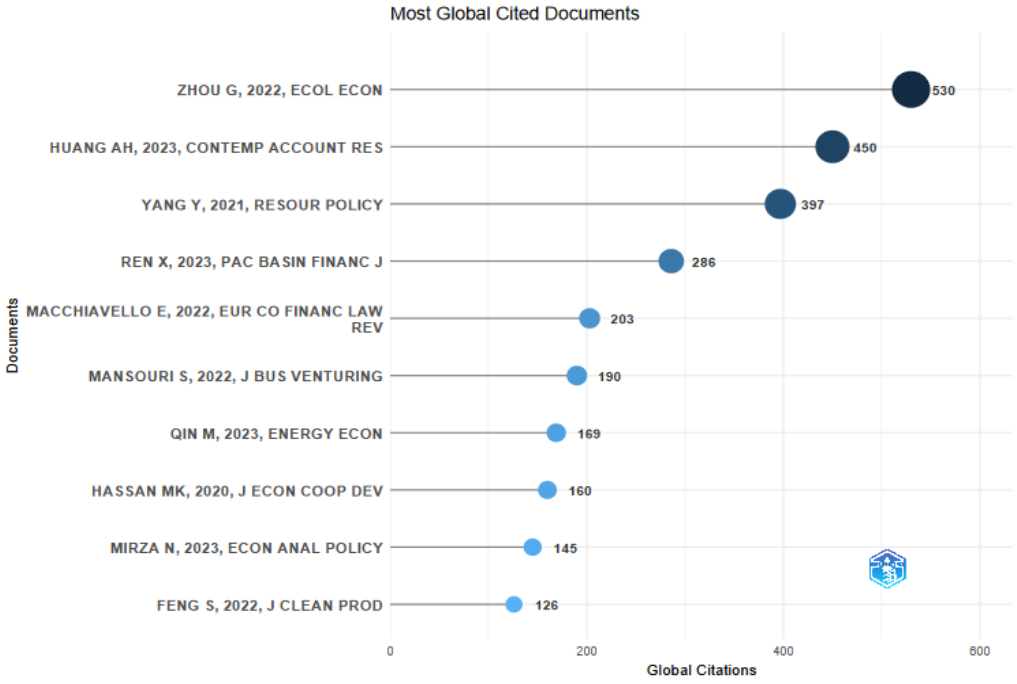

Fig 3: Most Global Cited Document Analysis

5.2 Network and Thematic Bibliometric Analysis

5.2.1 Keyword co-occurrence analysis

The key word co-occurrence map reveals that the central conceptual core of the domain consists of the concepts of green finance, fintech, sustainable finance, sustainability, machine learning and ESG (Khalegi et al., 2024). Such a pattern suggests that the literature is not just devoted to traditional green finance but is also structured through technology-led transitions towards sustainability(Widiastuti et al., 2025).

Figure 6 below shows that the close relationships between these nodes indicate high conceptual similarity, particularly between digital financial tools and more sustainable financial outcomes. The field has become interdisciplinary, and the incorporation of blockchain, AI, financial inclusion and green economy only reinforces the idea that technological innovation is a bridge between the financial transformation and the green economy(Carè et al., 2025). The analysis revealed that the literature is evolving from fragmented research themes to a more unified AI finance sustainability ecosystem, which is confirmed by this co-occurrence network (Nefla & Jellouli, 2025).

The overlay colouring also suggests a temporal shift from general conceptual themes to more specific analytical and applied themes, with an increasing focus on machine learning, digital transformation and environmental sustainability (Sharma et al., 2024). This is a significant indication of an emerging field becoming more methodologically and conceptually complex.

From a practical perspective, the co-occurrence network substantiates the focal of this study by demonstrating that digital green finance should not be viewed as two isolated subfields, it is rather an integrated and technology-enabled ecosystem driven by AI-based innovations (Dev et al., 2025; Ribeiro, 2024).

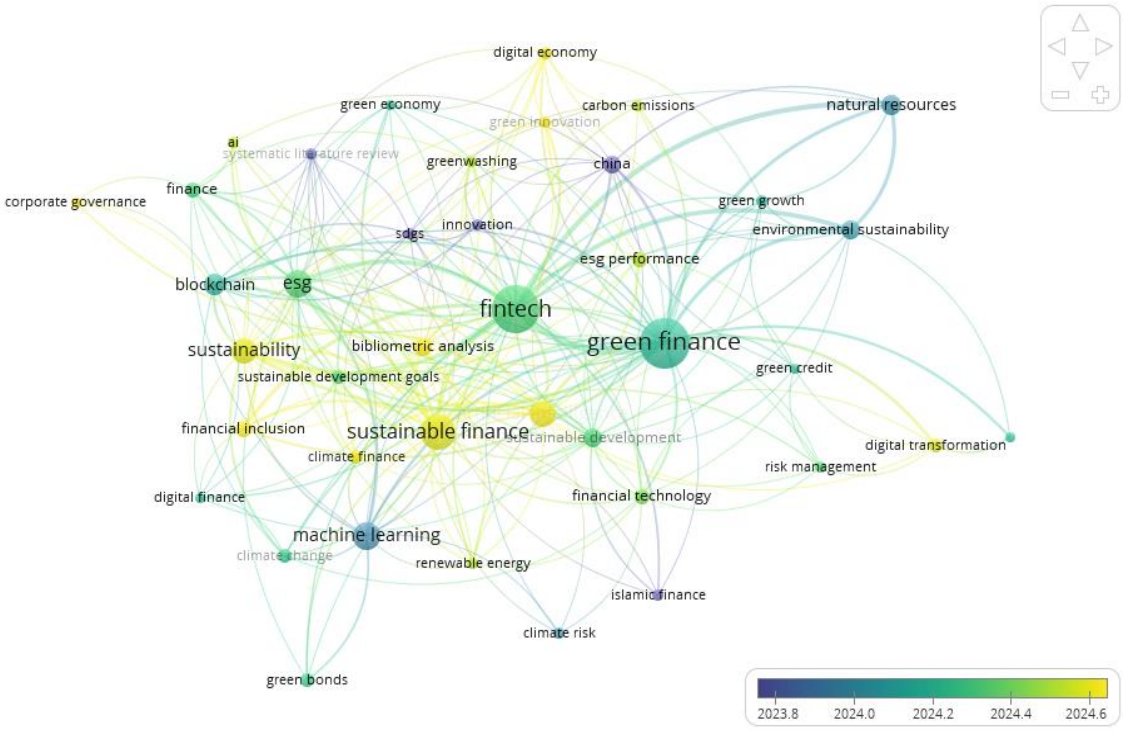

Fig 4: Keyword co-occurrence analysis

5.2.2 Co-citation and intellectual structure

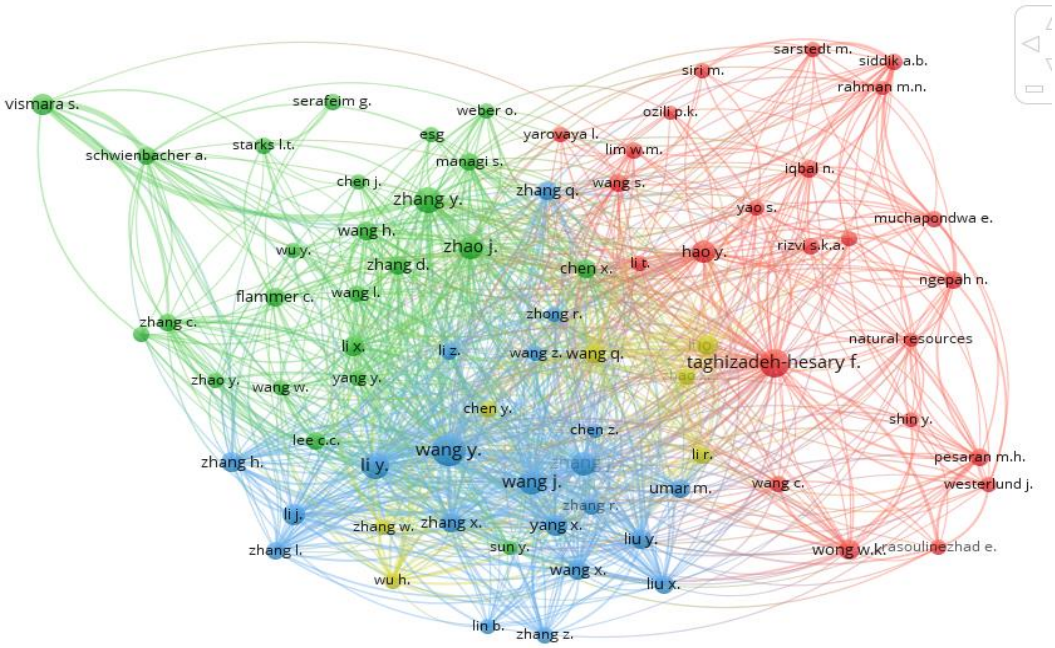

Fig 5: Co-citation and intellectual structure

The analysis does not illustrate a separate classical co-citation network, but the visualizations in Figure 7 below clearly show the intellectual underpinnings in the field. The most obvious mentions and authors are all associated with finance innovation, sustainable development, ESG performance and AI-driven analytics, suggesting that a relatively smaller number of influential studies are driving a significant amount of the work in this field (Fodol & Aslan, 2025; Safi et

al., 2024) This clustering depicts an emerging field where core papers give a conceptual blueprint for initial adoption and spreads out later. The structure of the citations indicates a developing but still converging field; there are key sources that hold the field together (Carè et al., 2025). The citations of the dataset suggest that there are three intellectual streams: substantive (green finance, sustainable finance); enabling (fintech, digital transformation); and methodologically technological (AI/ML, data-driven analytics) (Mohamed & Akande, 2025; Widiastuti et al., 2025).

5.2.3 Bibliographic coupling map

Bibliographic coupling pattern indicates that due to the shared reference to green finance, ESG performance, machine learning and digital finance, there exists a strong connection between the more recent studies. This connection indicates that the ongoing research is converging and contributing to shared intellectual resources to solve sustainability-based financial issues (Puschmann & Khmarskyi, 2024). Bibliographic coupling is particularly useful to determine the "current research front," and clarifies that the literature is shifting toward the new frontiers of AI-supported ESG measurement, green investment and digital financial innovation (Martin-Melero et al., 2025). The high density of these co-occurring clusters around China, green economy, sustainable development and financial technology also indicates that many of the recent studies are empirical, with a focus on country level data, firm level ESG outcomes, or financial market data (Bassi et al., 2025; Hassan et al., 2020). This is particularly useful in differentiating between mature and emerging clusters. It reinforces a new perspective that the field is becoming more application-driven (Boddu et al., 2025). The concept of coupling has also been applied in more recent bibliometric analysis of green finance and sustainable finance research areas to identify emerging research fronts and unexplored cross-sections (Macchiavello & Siri, 2022; G. Zhou et al., 2022).

Fig 6: Bibliographic coupling map

5.2.4 Thematic map

The first quadrant represents emerging or declining themes characterized by the low centrality and low density. Themes such as machine learning, blockchain, investments and AI-driven analytics are placed in this cluster, indicating that these areas are still evolving and have not yet attained conceptual maturity within the sustainable finance literature (Şencan, 2025). Their positioning still reflects the increasing scholarly attention toward AI-enabled ESG analytics, blockchain transparency and intelligent green-investment systems as future technological drivers of sustainable finance (Schulz et al., 2020; Wei et al., 2024).

The second quadrant consists of basic themes that possess high centrality but relatively low density, reflecting that these themes form the conceptual backbone of the field while remaining broadly dispersed across different research streams as shown in fig. 9. Fintech, green finance, finance and sustainable development emerge as the dominant themes within this quadrant, reflecting their foundational role in shaping the intellectual structure of AI-enabled digital green finance research (J. Wang et al., 2024). The findings reveals that the literature exists at the intersection of finance, sustainability, environmental economics and technological innovation rather than within a single disciplinary domain (Bassi et al., 2025; Khalegi et al., 2024)

The third quadrant reflects motor themes reflected by the both high centrality and high density, suggesting that these topics are conceptually mature and actively promoting the intellectual agenda of the field. Themes such as green economy, environmental economics, carbon emissions and sustainability transition dominate this quadrant, reflecting the growing integration of ecological concerns within financial and investment research (Nefla & Jellouli, 2025; Vongurai, 2025). Their strong positioning indicates that the literature is evolving beyond conventional financial instruments toward broader sustainability impact assessment, climate governance and environmental performance evaluation (X. Li et al., 2025).

The fourth quadrant represents niche themes characterized by high density but comparatively low centrality, indicating specialized yet relatively isolated research streams. Topics related to the blockchain-enabled transparency, decentralized finance, tokenized carbon system and ESG verification mechanisms are situated within this quadrant, reflecting technically advanced but narrowly concentrated domains of inquiry (Khalegi et al., 2024). Although currently peripheral to mainstream finance scholarship, these themes reveal high future relevance in enhancing the transparency and governance within digital green finance ecosystems (Manta et al., 2025).

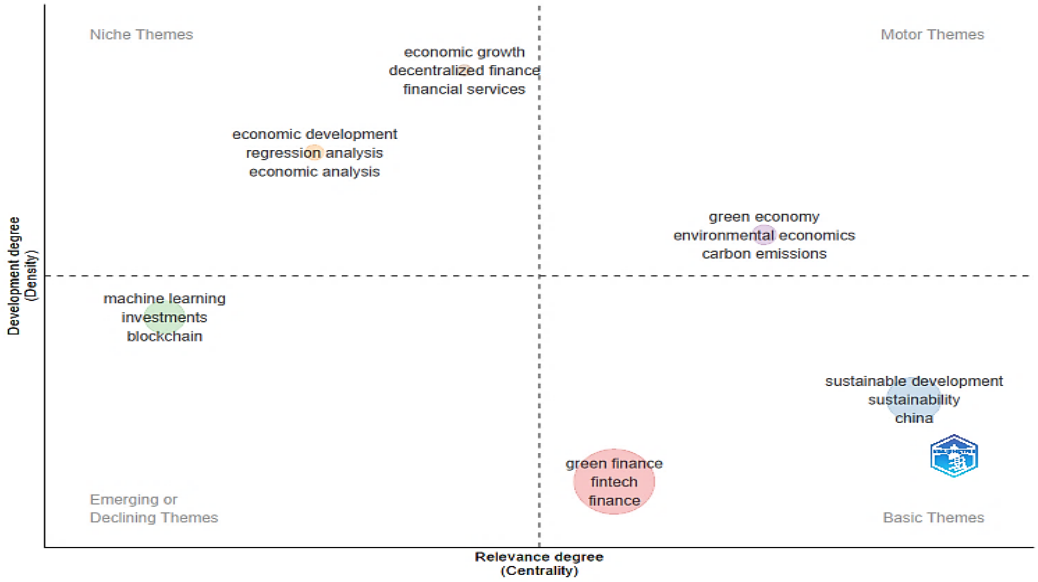

Fig 7: Thematic Map

5.2.5 Word cloud

The word cloud provides an instant overview of how prominent the terms are in the dataset. As shown in Figure 10 below, green finance, fintech, sustainable development, sustainable finance, machine learning, sustainability and ESG emerged as the prominent terms (Ding et al., 2024; Siddik et al., 2025). This indicates a high degree of convergence of the core ideas within

the literature. These terms are interrelated and green finance is the principal anchor term. Interestingly, the size of fintech and machine learning defines how digital technologies conceptualises sustainability finance. A word cloud is a description of the text, not an analysis of it in itself, from a manuscript point of view(Aassouli et al., 2025; S. R. Sethi & Mahadik, 2025). It is helpful in measuring keyword frequency, validating the thematic and co-occurrence map analyses of the core concepts (Lucarelli et al., 2024).

Fig 8: Word Cloud

5.2.6 Tree map

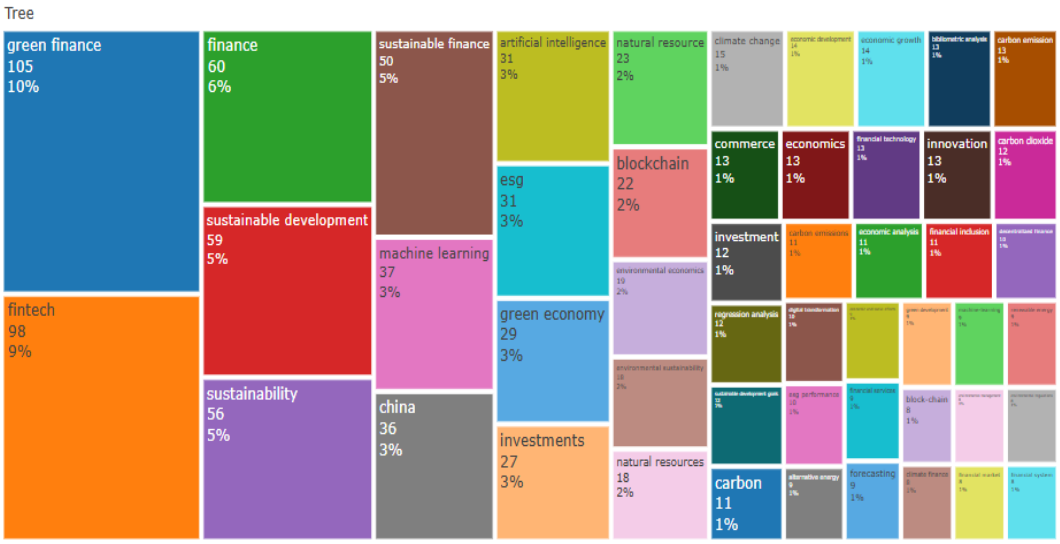

Fig 9: Tree Map

A treemap provides an organized view of the frequencies than the word cloud does. Figure 11 below reflects that green finance, fintech, sustainable development and sustainability acquire

dominant positions in the literature (Mamun & László, 2025) Sustainable finance, machine learning, China, artificial intelligence, ESG, green economy and investments suggest the growth of a niche area technologically as well as contextually (Metawa et al., 2022; Rapach et al., 2024). Surprisingly, the tree map strikes a balance between the conceptual terms as well as the application-oriented terms. While the field is rooted in general concepts like sustainability and green finance, it now seems to be integrating with digital tools and analytical approaches, like AI and machine learning (Puschmann & Khmarskyi, 2024). These frequency distributions can help researchers to choose the themes that would benefit from a thorough exploration using literature review (Pandey, 2025; Xu et al., 2023).

5.2.7 Three-field plot

The three-field plot brings together references, authors and keywords revealing how intellectual sources will be translated to thematic production. The keywords in the plot are related to the major authors with green finance, machine learning, fintech, sustainability and sustainable development. This suggests that the field organized and a cohesive group of authors is continually linked to a relatively stable group of influential concepts(Harinathan et al., 2025; Zournatzidou, 2025). Figure 12 below shows the connection between literature from the foundation and current thematic developments. The three columns across the rows from left to right offer an intellectual basis, the most active contributors to the field and the changing conceptual vocabulary. Three-field plots are frequently used in hybrid review papers suggesting the flow of knowledge and thematic inheritance in order to enhance the intellectual depth of the paper (Ashurbayli-Huseynova & Garmidarova, 2025; Fodol & Aslan, 2025).

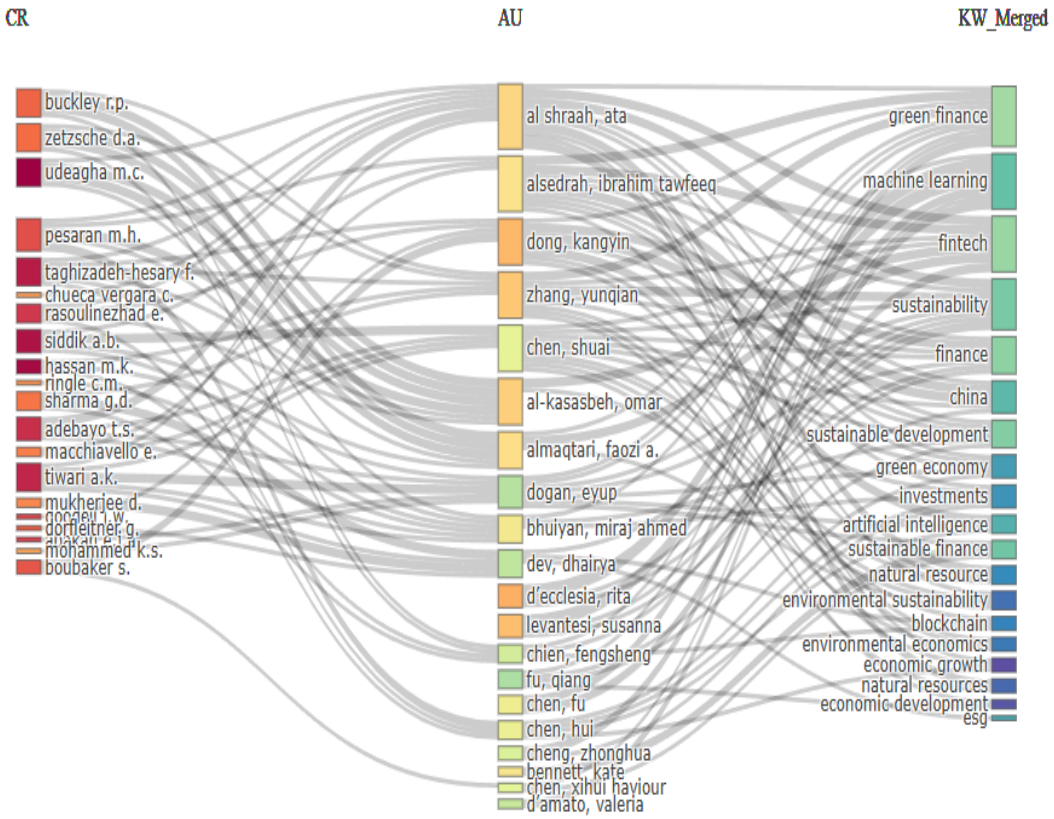

Fig 10: Three-field plot

5.2.8 Trend Topics Analysis

The analysis of the trend topics shows the following most salient research areas such as green finance, fintech, sustainable finance, artificial intelligence and ESG. The trend towards more frequent and longer lasting terms highlights the shift from traditional sustainability-finance research to a technologically driven financial ecosystem. The rise of forecasting and AI-related themes also indicates an increasing focus in the academic world on predictive analytics, climate-risk assessment and automated ESG evaluation systems (Jellouli, 2025; Portillo-Tarragona et al., 2025).

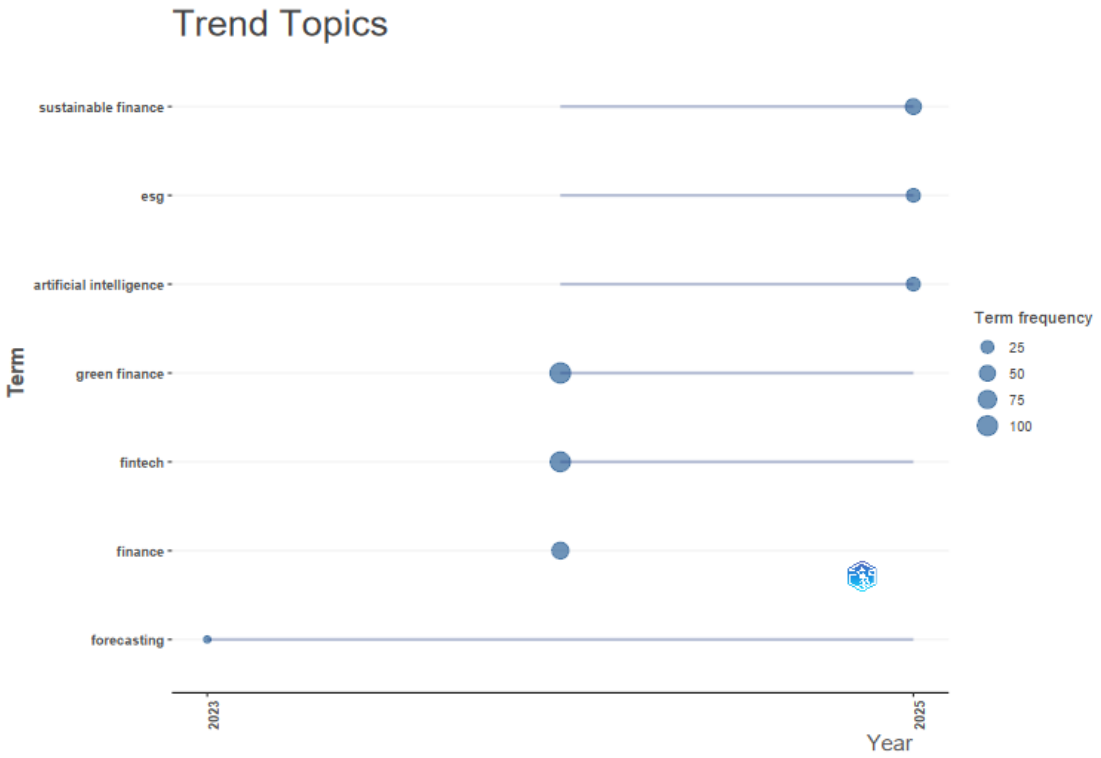

Fig 11: Trend Topics

5.2.9 Country scientific production

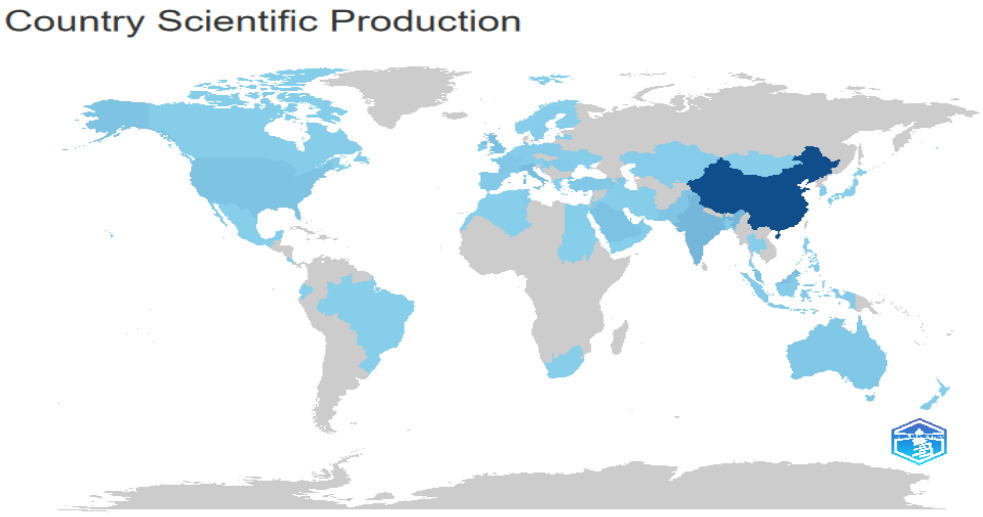

Fig 12: Country scientific production

As found earlier, Chinese leadership is followed by India, United States, Italy, United Kingdom and Malaysia. China has emerged as a significant force for research in green finance, digital finance innovation, ESG experimentation and sustainability research using AI(Ashurbayli-Huseynova & Garmidarova, 2025; Brusseau, 2023; M. Yang et al., 2025). The geographical distribution of scholarly writing from Asian researchers signifies that AI-driven digital green financing being a global phenomenon but not equally shared across regions, and bears a regional dimension to it. Hence, the significant role of emerging economies extends to the Global South where issues like financial inclusion, climate risk and sustainable development are critical (Chien et al., 2025; Gao & Ju, 2025).

5.2.10 Country Collaboration Network Analysis

The VOSviewer country collaboration network highlights China as the central collaboration hub within the global AI-enabled digital green finance research landscape. Strong collaborative linkages are visible between China, Malaysia, the United Kingdom, the United States, India, and several Middle Eastern and European economies(Alsedrah, 2024). The dense inter-country linkages demonstrate an increasing internationalization of sustainability-finance research and the interdisciplinary nature of digital green-finance innovation. Furthermore, the collaboration structure suggests that the emerging economies are actively participating in global sustainability-finance knowledge production, particularly in areas related to fintech, ESG systems, and green economic transformation (Metawa et al., 2022; Platania et al., 2025; S. R. Sethi & Mahadik, 2025).

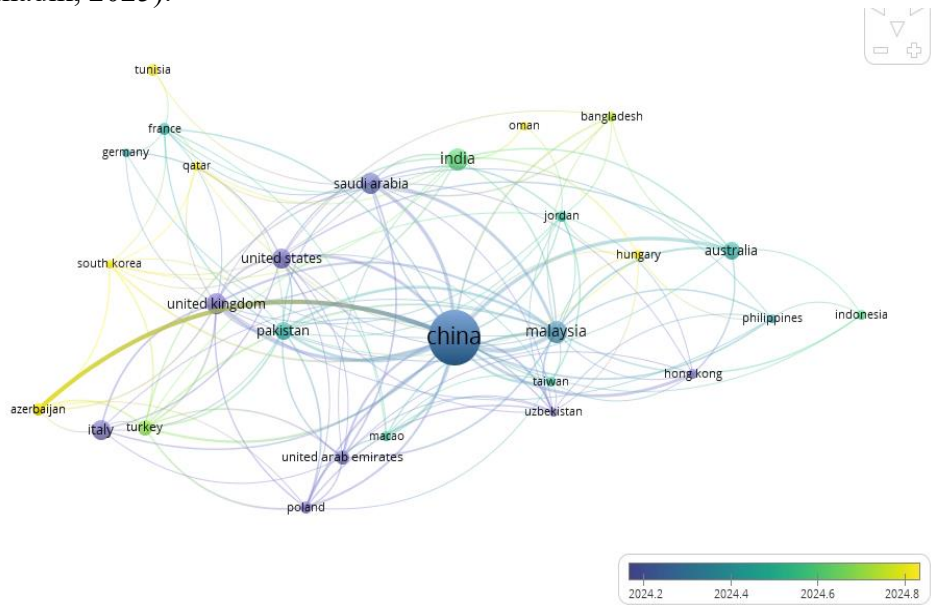

Fig 13: Country Collaboration Map

6. SYSTEMATIC LITERATURE REVIEW AND THEMATIC CONTENT ANALYSIS

6.1 Overview of thematic evolution

The detailed literature review of the 80 articles filtered for this study reveals that the field is a burgeoning, interdisciplinary and technology-centric research area that encompasses sustainability, fintech innovation, ESG governance and financial data driven analytics. The field can be distilled into five main research streams from the thematic synthesis: (a) AI

supported ESG analytics and sustainable reporting, (b) blockchain and transparency in sustainability, (c) green fintech and financial inclusion, (d) AI in climate-risk analytics and sustainable investment systems, and (e) ethics, governance and algorithmic bias in digital green finance. The literature emphasizes the transformative power of AI, machine learning, blockchain and digital financial systems on sustainable finance in each of these thematic areas. Digital technologies in these studies, not only serve as solutions but tools for assessing ESG, climate risk management, optimising sustainable investments, distribution of green credits, and environmental governance (Macchiavello & Siri, 2022). Meanwhile, the literature highlights institutional and ethical challenges including the quality of governance, the regulatory oversight of digital green finance, explainability and information asymmetry of the digital green finance market (Mamun & László, 2025; Ray et al., 2025).

6.2 AI-powered ESG analytics and sustainability reporting

There is a growing consensus in literature that AI-based analytical systems enhance efficiency, objectivity, and predictive power of financial decision-making considering ESG-related issues by automating the extraction and interpretation of sustainability-related information from financial disclosures, corporate reports, and unstructured text datasets (Zhu & Zhou, 2025). The expanse of influential studies reveal positive impacts of AI on transparency in ESG reporting as it decreases information asymmetry while increasing the reliability (Luo & Zhang, 2025). More specifically, the utilisation of newly launched advanced NLP models such as FinBERT have transformed the ESG analytics, providing automated sentiment analysis, identification of sustainability risks, and interpreting the financial communication of the companies in real-time (Y. Huang, 2025). These techniques are increasingly used by institutional investors, banks, ESG-rating agencies and policymakers to improve the screening and monitoring of sustainable investments with regard to environmental risks (Brusseau, 2023). Apart from NLP, another key emerging stream is the utilisation of predictive ESG analytics. Machine learning models are outperforming the traditional econometric approaches for forecasting ESG performance, green innovation results, and sustainability-related financial risks (Kumar & Mohanty, 2025). The major benefit of AI-driven systems is their capacity to evaluate vast amounts of financial and environmental data concurrently to generate more precise and timely sustainability evaluations (Harinathan et al., 2025). The literature further indicates that the introduction of AI tools for ESG is linked to increased sustainability performance of the company, such as promoting transparency and better disclosure quality(Şencan, 2025). However, because of the algorithmic nature of these ESG systems, the scholars argue governance challenges such as explainability constraints and reliance on data quality (Nefla & Jellouli, 2025). Majority of the existing research is conducted on large listed companies and emerging-market sustainability ecosystems whereas the SMEs are under-researched. Theoretical grounding of these studies is based on established works like the stakeholders' theory, institutional theory and information asymmetry theory. Institutional theory and information asymmetry theory serve as a powerful duo that provides a complete picture of how AI-driven ESG systems help in improving the stakeholder trust, disclosure inefficiencies, and institutional legitimacy in the area of sustainable finance (Manta et al., 2025; Toscano Hernandez et al., 2025).

6.3 Blockchain and transparency mechanisms in sustainable finance

Another emerging area of research is blockchain technology for improving transparency, setting-up anti-greenwashing, verifying carbon credits, and developing a decentralized sustainable financial system(Toscano Hernandez et al., 2025) The literature indicates that such a blockchain-based financial system can be a key to improving accountability and traceability

in the sustainable finance markets. Several studies have pointed out that blockchain technology can enhance the credibility of green financial instruments, especially green bonds, carbon market systems and ESG investment systems (Tlili, 2025). Blockchain can be used to help reduce transaction manipulation risk and improve investor, regulatory and financial intermediary trust by offering secured sustainability verification (Khalegi et al., 2024). Blockchain is increasingly viewed as a technical solution to tackle opportunistic sustainability behaviour and enhance governance of green finance (Kazachenok et al., 2023).

A discourse regarding relation between greenwashing and blockchain has recently surrounded the efficacy of the verification protocols of traditional ESG reporting systems, allowing companies the luxury to claim sustainability without facing any punishment if it's ultimately disclosed. However, blockchain-based systems overcome shortcoming by providing a secure and tamper-resistent sustainability record and a transparent environmental auditing procedure (Mzoughi et al., 2024).

The combination of blockchain and AI has garnered a growing interest in literature for the development of more intelligent and autonomous sustainable financial ecosystems. By leveraging transparent distributed-ledger systems and predictive AI analytics, this integration will boost the allocation of green-credits, tracking of sustainability risks, and governance of climate finance (Cai et al., 2024; Mzoughi et al., 2024)

6.4 Sustainability of fintech and financial inclusion

A recurrent relationship between sustainable finance and fintech innovation is found in the literature. This theme contributes from digital financial technologies to green economic transition, sustainable financial inclusion and climate related development goals in emerging markets (Chien et al., 2025). Numerous studies indicate that fintech systems provide accessibility to sustainable financial services, financial environment, and enabling sustainable financial investment behavior by reducing cost of transactions (Mamun & László, 2025). These newer technologies are perceived as valuable for sustainable financial inclusion especially for those who are under-served by the existing financial system, including mobile banking, digital-payment ecosystems, digital microfinance systems, P2P lending platforms and green crowdfunding mechanisms (Ahelegbey et al., 2023). Similarly, other empirical studies show that fintech innovation bears significant positive impact on carbon efficient, green and sustainable economic and industrial growth(Al Doghan & Chong, 2023).

Digital-finance ecosystems enhance the connection between green finance, high-quality economic development, more efficiently harnessed capital and a more conducive environment for green innovation investment (Teichmann et al., 2024). Moreover, companies with a higher level of digital-finance integration perform better in better ESG criterion, due to the increased transparency, availability of data and efficiency (Wei et al., 2024). Furthermore, fintech enhances climate resilience and sustainable SME financing (Kashif et al., 2025).

Digital financial systems increase access to green-finance markets, especially by filling the geographical and institutional gaps that have traditionally been a characteristic of sustainable finance markets (Matta et al., 2025). Moreover, there is a lack of research on long-term effects of the adoption of fintech services on the environment. In this regard, Technology Acceptance Model, the Innovation Diffusion Theory and Resource Based View theories provide the link between technological capabilities, digital readiness, digital innovation, sustainable financial transformation and competitiveness of the organisations (Han & Gao, 2024; Widiastuti et al., 2025)

6.5 AI-based climate-risk analysis and sustainable investments systems

A prominent stream of literature examines the application of artificial intelligence, machine learning and big data analytics in climate-risk assessment, sustainable investment management and green financial decision-making as shown in below fig. The extant literature acknowledges the limitations of traditional financial models associated with environmental uncertainty, climate volatility, and climate-related ESG financial risks (Alonso-Robisco et al., 2025). AI-powered predictive systems are now, therefore, emerging as integral tools for sustainable investment research. Machine-learning algorithms provided a boost to forecasting of climate risk, carbon-emission modelling, and the allocation of sustainable investments (Yin et al., 2025). AI-enabled systems are particularly effective at identifying climate risks, predicting sustainability market turbulence and optimizing green investments during economic uncertainty and environmental crises(L. Li et al., 2025). AI-driven systems are particularly effective at identifying climate vulnerabilities, forecasting market volatility around sustainability and green investments (Yao & Yang, 2025). Furthermore, AI-powered investment platforms to enhance the efficiency of sustainable finance by embedding ESG considerations into dynamic investment strategies has been reported (Abdalla et al., 2025). AI-enabled financial systems support environmental sustainability in various ways, such as allocating green credits, financing the development of renewable energy, and promoting sustainable and low-carbon practices in the industry, as indicated by many studies (S. Feng et al., 2024). The results show that AI-based financial systems transform investment decisions significantly impacting the overall sustainability-transition process. Thus, the existing body of literature calls for governance, comparative and longitudinal studies of ethical and institutional aspects of climate-finance systems supported. This theme is built on the foundations of Resource-Based View, Stakeholder Theory and Dynamic Capability Theory that help to understand how digital capabilities generate sustainable competitive advantage and organisational resilience in the context of uncertainty (Baklouti, 2025; Miglionico, 2022).

6.6 Ethics, governance, and algorithmic bias in digital green finance

The last, but increasingly important, is the governance quality and ethical responsibility towards algorithmic bias and regulation in AI-driven green-finance systems. Digital technologies advance sustainability analytics and financial efficiency, at the same time there are looming concerns regarding production of new opacities, exclusions and institutional risks (Brusseau, 2023). Furthermore, studies suggest that AI models trained on historically-biased data end up marginalizing SMEs, low-income areas, and even sustainability initiatives with less digital presence (M. Wang et al., 2025). Therefore, scholars stress on the importance of AI governance frameworks promoting fairness in making financial systems inclusive and accountable. Furthermore, governance of data and digital green-finance cybersecurity are new entrants to the discourse (Nefla & Jellouli, 2025). With the growing data-driven nature of sustainable finance systems, issues surrounding privacy safeguarding, ESG data manipulation, cyber risks and cross-border regulatory coordination gain significance(Ferrara & Ciano, 2024). The literature thus focuses on the need to enhance the quality of institutional governance, in addition to the sophistication of the technologies (C. Wang et al., 2024) to achieve the sustainable financial transformation. Agency Theory, Institutional Theory and Information Asymmetry Theory support this thematic stream indicating transparency, accountability, and governance legitimacy in AI-driven financial systems. In summary, the literature indicates that while technological innovation is a key factor, ethical governance, institutional trust, and regulatory flexibility are crucial for the long-term success of AI-enabled digital green finance (M. Sethi et al., 2025; Zhu & Zhou, 2025).

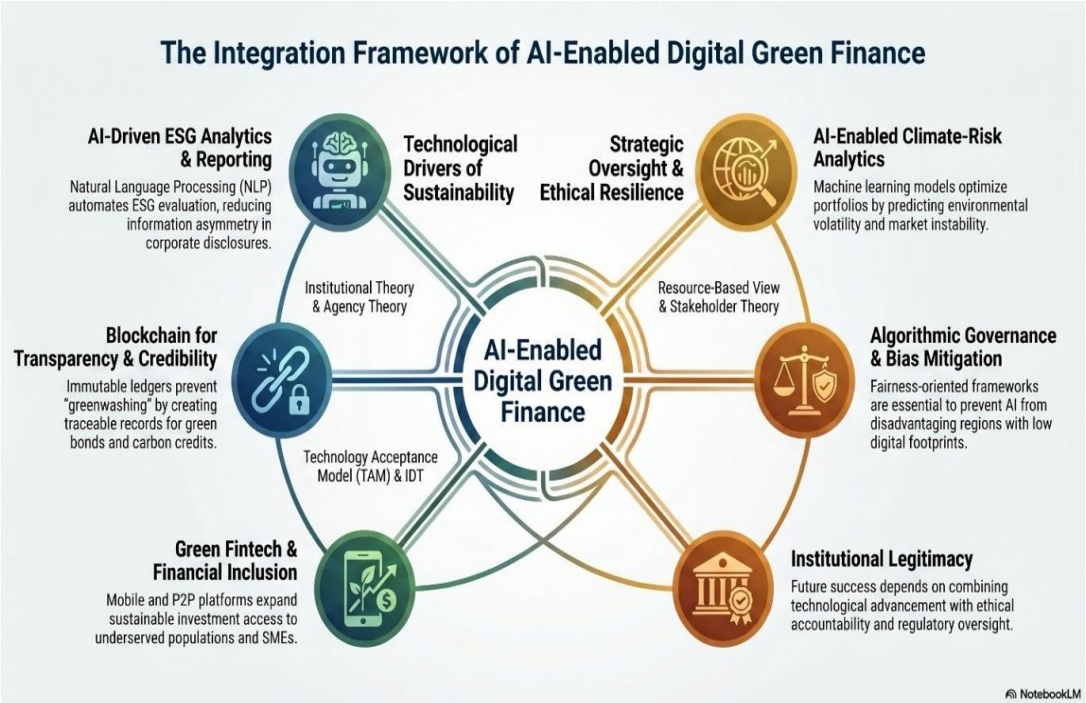

Fig 14: Integration Framework of AI-Enabled Digital Green Finance

Source: Generated through NotebookLM

7. DISCUSSION

The results reveal that AI-based digital green finance is not just a collection of topics that are "next door" to each other but a holistic interdisciplinary research field. The bibliometric pattern strikes a surge in publications from 2022 and onward, the dominance of China, as well as the concentration of publications around Resources Policy, Finance Research Letters and Energy Economics suggests that an exploratory phase of the field is being superseded by a more policy-oriented period. While previous reviews have examined green finance, fintech and AI powered sustainability independently (Fotova Čiković et al., 2025; Jangid et al., 2025; Roy & Vasa, 2025), the present review advances the literature by integrating these fragmented streams into a unified digital green finance perspective. Specifically, it uncovers how AI, fintech, blockchain, ESG analytics and sustainable finance are converging to form an interconnected technological ecosystem for addressing environmental and financial challenges (Ma et al., 2025). By combining bibliometric mapping with thematic synthesis, this review not only identifies the intellectual structure and emerging research frontiers of the field but also develops a future-oriented research agenda that links technological innovation with sustainable financial transformation. From a thematic point of view, the review identifies five themes that are interrelated: (a) AI-based ESG analytics; (b) Blockchain-based transparency; (c) Green fintech and financial inclusion; (d) AI-enabled climate-risk analytics, and (e) Governance and ethics. These themes indicate that digital technologies are not merely supporting mechanisms but constitute a core enabling infrastructure for the ESG measurement, sustainable investment decision making and green finance governance. The co-occurrence map identifies the presence of machine learning, fintech and ESG, while green finance and sustainability in the thematic map further confirms the maturity in the field. The theme is grounded in the traditional concepts of the financial sector but ripe enough for technological innovation (Alsedrah, 2024; Omri et al., 2025; Zhao et al., 2024). The field is shifting from financing to a digital decision support

system in the field of green finance. The shift is seen as growing integration of AI into ESG scoring, blockchain verification against greenwashing and machine learning in climate-risk modelling and green portfolio optimisation (J. Huang et al., 2024). At the same time, the literature highlights a paradox: the more sophisticated the technology, the more apparent the issues of explainability, quality of governance, algorithmic bias and information asymmetry (C. Wang et al., 2025). The domain is normatively contestable highlighting the need for greater theoretical integration within the stakeholder theory, institutional theory, agency theory as well as information asymmetry theory (L. Qin et al., 2024). Methodologically, the existing literature remains heavily concentrated in the Chinese context while comparative and Global South perspectives remain underrepresented (Fan & Lin, 2025; Ouni et al., 2025). This geographical concentration limits the generalizability of the findings, particularly because the effectiveness of AI enabled sustainable finance depends on the country specific regulatory frameworks, digital maturity and institutional conditions (Ibrahim et al., 2024; W. Wang et al., 2025).

8. POLICY ISSUES AND IMPLICATIONS

Theoretically, this review advances theory by demonstrating that AI-powered digital green finance is no longer just green finance and fintech, but a new interdisciplinary field that is characterised by technological potential, institutional acceptance, stakeholder responsibility and information transparency(Bhuiyan et al., 2024). The five streams of themes identified in the literature suggest that the next steps in theory building should embrace various theories within a more comprehensive framework of digital sustainability finance as informed by previous reviews that suggest a theory-informed synthesis instead of descriptive mapping (Chishti et al., 2024; C. Wang et al., 2024).Methodologically, the study shows that bibliometric analysis and thematic SLR are complementary and indispensable. These map the intellectual structure of the field, as well as the conceptualization and operationalization of the themes used to describe the field in the literature (Y.-S. Ren et al., 2023). The present review proposes that hybrid designs should be considered as the standard approach in emerging states for more integration of the concepts.

Over the time, digital technologies have become a functional necessity for managers, investors and financial institutions to implement sustainable finance (Abdalla et al., 2025). The present study thus warns of the potential unclear models and skewed ESG outcomes and a lack of accountability if technology is not well governed. Therefore, businesses must combine digital innovation, explainability, human supervision, and sustainability governance mechanisms to achieve efficiency and trust for digital green finance (Jia et al., 2025). This review, hence, highlights the need for better disclosure requirements on governance of AI, blockchain verification and data quality standards for ESG information transparency for policymakers and regulators (Dadabada, 2025). The impact of China, and the growing role of emerging economies in the field point towards a policy experiment is shaping the domain (Baklouti, 2025). So it needs more effort to foster responsible adoption of explainable AI standards, anti-greenwashing regulations, digital-finance sandboxes, and interoperable ESG reporting frameworks, among other measures, by regulators (Harinathan et al., 2025; D. Zhang, 2024).

9. LIMITATIONS AND SCOPE FOR FUTURE RESEARCH

The present bibliometric analysis contains data from Scopus, other databases such as web of science, dimensions, google scholar, and discipline-specific databases are yet to be explored. Furthermore, it is important to note that this review does not provide a comprehensive overview from related disciplines such as accounting, computer science, environmental economics, and

public policy. Secondly, the refined data limited after using filters provided articles published in 2020-2025. This might have excluded earlier conceptual bases and non-English literature that provide theoretical and regional perspectives that could be useful. Although the selected time horizon may not capture the entire historical evolution of the field, it provides a robust representation of the most recent intellectual developments and the emerging research trajectories in AI enabled digital green finance (Tian et al., 2025; Zhuang, 2024). Thirdly, even though the articles were considered to include and exclude according to explicit criteria, the final selection of 80 articles was the result of a manual screening process based on the relevance of the articles, which introduces interpretative judgment. This can provide a focus on conceptual aspects, but can also mean that studies on the periphery bearing important consequences might be under-represented (Lyu et al., 2025; Zournatzidou, 2025). A limitation of this hybrid review is the trade-off between comprehensive literature coverage and in-depth thematic synthesis. While some relevant studies may have been excluded due to the database and screening constraints, the review captures the most influential and methodologically robust contributions, thereby providing a reliable overview of the field's intellectual development and future research trajectory (Ke et al., 2025; Nepal et al., 2025). Lastly, bibliometric measures like citations, co-occurrence and journal productivity provide proxies of influence, but often fail to highlight novel ideas in theory, relevance to practice and emerging contributions which have not yet been sufficiently cited. Rather than offering an exhaustive evaluation of the field's cumulative scholarly contributions, the present analysis provides an evidence based mapping of its contemporary intellectual landscape, highlighting the dominant research trajectories, thematic developments and the emerging knowledge domains within AI enabled digital green finance (Song & Hao, 2024; Tian et al., 2025).

This review lists future research opportunities that exist regarding the following research questions:

RQ1. What is the similarity between AI-based green-finance relationships in emerging, developed and transition economies?

Geographical concentration, limited geographical (fewer comparisons between economic systems) and institutional discontinuity. Future research should investigate the moderating role of regulatory quality and institutional maturity, financial development, and digital infrastructure in the relationship between AI and green finance across countries (Chien et al., 2025). This is grounded in the theoretical background on institutional theory and on comparative governance, which suggests that regulatory and socioeconomic conditions have an impact on the results of the sustainability-finance. From the methodological point of view, future research will rely on multi-country panel regression and on cross-national SEM models and configurational analysis with the fsQCA Fuzzy-set Qualitative Comparative Analysis approach to take into account the institutional differences and contextual complexity. These would help increase external validity and further spread the theory of sustainable-finance by AI into the international community (Hu et al., 2025; Narayan et al., 2025).

RQ2. How does explainable AI and agentic AI differ in the ESG prediction area, in terms of transparency and accountability in sustainable finance?

The number of AI tools used for ESG analysis has increased exponentially, but none of the scholars investigated these tools, or explained them and accounted for algorithms used, and showed transparency of governance(Ali et al., 2025). Many of the current prediction models are "black-box" models, and there are concerns about bias, model interpretability, and stakeholder trust (C. Wang et al., 2025). Future research should assess the effect of explainable

AI (XAI), agentic AI, and interpretable machine learning systems on the reliability of the ESG and sustainability governance and disclosure credibility grounded in the agency theory and information asymmetry theory. AI-powered analysis, NLP-based models, experimental designs, or a combination of these approaches can be used for governance assessment and predictive modelling (Suárez Giri & Sánchez Chaparro, 2024; Tian et al., 2025).

RQ3. What are the implications of the results of longitudinal, panel, and/or quasi-experimental studies on the causal effects of AI on green-finance performance?

The extant literature is predominantly cross-sectional and correlational, therefore, limited in causal conclusions regarding the outcomes of AI-enabled sustainability. The use of methods like longitudinal panel data, quasi-experimental techniques, difference-in-differences analysis and dynamic panel estimators would be useful in future studies to assess the long-term impact of AI on the efficiency of green finance, ESG performance, climate resilience, and sustainable investment outcomes (Narayan et al., 2025; Zournatzidou, 2025). From a theoretical standpoint, this direction fits in with the paradigm of long term technological capability building in the resource based view and the dynamic capability view of organizational adaptation. Such studies would greatly enhance the methodological rigour and causal validity of the field (Ibraimova et al., 2025; Ijaz et al., 2025).

RQ4. How can green fintech and AI financial systems contribute to achieving sustainable finance for SMEs and the underserved?

Numerous studies focused on the institutional investors, large corporations or on macro-sustainability outcomes in comparison to SMEs, informal sectors and financially underserved populations(Ma et al., 2025). Future studies may explore AI-powered fintech systems and digital lending platforms, green crowdfunding platforms, and decentralized financial technologies to improve sustainable financial inclusion and access to climate finance (Mahajan et al., 2024). Supported by the stakeholder theory on equity in access to sustainability oriented financial systems and financial inclusion theory. The methodological approach could be case studies, field surveys, mixed methods and/or platform-based analytics for developing economies in the future to build the social and developmental effects of digital green finance research (Boddu et al., 2025; Jia et al., 2025).

Finally, future research should be more integrated, theory oriented and policy oriented to better understand how AI technology can enhance not just financial efficiency, but sustainability governance, institutional legitimacy, climate change resilience and inclusive green economic transformation (Kumar & Mohanty, 2025; Metawa et al., 2022).

10. CONCLUSION

The rapid convergence of artificial intelligence, fintech, ESG systems and sustainable finance has transformed digital green finance into a strategically important and theoretically evolving. Through the integration of the bibliometric analysis and systematic literature review, this study synthesized the intellectual structure, thematic evolution and emerging trajectories of AI-enabled digital green finance research between 2020 to 2025. The findings highlight that the field is increasingly organized around the interconnected themes such as AI-driven ESG analytics, blockchain enabled transparency, green fintech inclusion, climate risk modeling and governance enabled sustainability systems. The review further demonstrates that digital technologies are no longer peripheral instruments within sustainable finance; rather, they are becoming central infrastructures shaping sustainable investment, ESG governance and climate-oriented financial transformation. However, the literature remains scattered across theoretical,

methodological and institutional dimensions, with limited cross-country evidence, inadequate focus on explainable AI and underdeveloped governance oriented frameworks. By integrating science mapping with thematic synthesis, the study provides an integrated understanding of the intellectual architecture of the field while identifying critical future research directions for institutional heterogeneity, ethical AI governance and inclusive green-finance ecosystems.

The study also provides important implications for the policymakers, financial institutions, sustainability practitioners and budding researchers seeking to develop the transparent, accountable and technologically resilient sustainable-finance systems and theories in the emerging digital economy.

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