Review

Mapping the Sustainable Finance Knowledge Base: Evolution, Focus, and Future Direction

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Abstract: Sustainable finance has emerged as a pivotal mechanism for aligning financial flows with environmental, social, and governance objectives, helping to address climate change, biodiversity loss, and social inequities. Its rapid expansion, coupled with the diversity of stakeholders—ranging from academics and policymakers to financial institutions, NGOs, and rating agencies—demands a clear understanding of how the knowledge base in this field has evolved. This study addresses the question: How has sustainable finance research developed over time, what are its thematic foci, and where is it heading? Drawing data from "the Scopus database", the research utilized the "PRISMA" methodology for selection and evaluated 419 manuscripts using "the VOSviewer" software. The findings indicate that sustainable finance research is still in its infancy due to the fact that it began to emerge in 2019, with significant attention given to areas such as the fintech ecosystem, financial inclusion, digital financial inclusion, green digital finance, sustainability, and ESG investments. Additionally, the study found a clear correlation between the number of publications a scholar has and the citation counts received. It also highlights that sustainable finance research is predominantly concentrated in developed countries, with minimal contributions from developing nations. Overall, the study offers valuable perspectives on the historical development, current trends, and future directions of sustainable finance trajectories. This research contributes significantly to the field of "sustainable finance" by examining bibliometric data, retrieved from the "Scopus database", through the analysis of major trends that have emerged in "sustainable finance" studies. It further enhances value by highlighting the developing areas within this domain.

Keywords: digital finance; sustainable digital finance; sustainable finance; VOSviewer

1. Introduction

The global financial landscape has experienced a profound shift toward sustainability, spurred by the growing recognition that long-term economic prosperity cannot be divorced from environmental stewardship and social equity. As "climate change", "biodiversity loss", and "social inequality escalate", "sustainable finance" has appeared as a transformative paradigm that redefines how capital is allocated and utilized in addressing environmental, social, and governance (ESG) challenges (Schoenmaker & Schramade, 2019). "Sustainable finance" is broadly defined as encompassing financial services and investment strategies that incorporate ESG factors into corporate and "investment decision-making processes", thereby promoting inclusive economic growth, reducing environmental risks, and concurring the accomplishment of "the United Nations Sustainable Development Goals (SDGs)" (United Nations, 2015; OECD, 2020).

Several theoretical frameworks underpin research in sustainable finance. One of the most prominent is "stakeholder theory by Freeman in 1984", which posits that firms have responsibilities beyond shareholders and must account for the benefits of all "stakeholders", including employees,

communities, and the environment (Andrews et al., 2010). This perspective supports the idea that financial decisions should be aligned with broader societal goals.

"The resource-based view (RBV)" has also been useful to explain how ESG capabilities can generate a competitive advantage. Firms that strategically integrate sustainability into their operations may build unique, inimitable resources that enhance performance (Barney, 1991; Harts, 1995). Institutional theory, in contrast, has been used to examine how regulations, norms, and cultural expectations influence the diffusion of sustainable finance practices (Campbell, 2007).

The proliferation of green bonds, ESG investing, climate risk disclosures, and "socially responsible investing (SRI)" frameworks is testimony to the rising momentum of sustainable finance across global markets. Governments, institutional investors, central banks, and multinational companies are gradually integrating "sustainability" metrics into their administrative procedures, determined by mounting regulatory pressures, "stakeholder" expectations, and financial materiality (Monasterolo & Raberto, 2018). At the same time, the academic community has responded with a surge of interest in sustainable finance, leading to a rapid expansion in scholarly output aimed at exploring its conceptual foundations, methodological approaches, and practical implications (Busch et al., 2016; Wang & Zhi, 2016). However, despite this growing body of research, there remains a lack of consolidated understanding regarding the intellectual structure, thematic evolution, and emerging frontiers within the sustainable finance literature.

"Bibliometric study—a quantitative method for analyzing scientific literature" based on publication and citation data—offers a robust approach to systematically map the development and structure of information in a given study realm (Donthu et al., 2021). This method permits academics to trace the evolution of scholarly work, identify influential authors, institutions, nations, and journals, and uncover thematic clusters and intellectual trends that shape the discourse (Priyan et al., 2023). Recently, bibliometric techniques have been increasingly applied to various subfields of finance and sustainability (e.g., ESG investing, green bonds, impact investing), yet a comprehensive bibliometric review focused explicitly on the knowledge base of sustainable finance as an integrated field remains underdeveloped.

This bibliometric review fills that gap by systematically analyzing the scholarly landscape of sustainable finance, drawing on a wide array of bibliometric indicators such as publication output, citation patterns, "co-citation networks", and co-occurrence of keywords. In doing so, it aims to map the contours of the field, highlight key intellectual contributions, trace the evolution of core themes, and identify research frontiers that warrant further scholarly attention. This work is not only timely but also essential, given the key role of "sustainable finance" in addressing planetary boundaries and social resilience in the Anthropocene era.

1.1 Sustainable Finance: Scope and Complexity

"Sustainable finance" is a multidimensional construct that intersects with various disciplines, including environmental economics, corporate governance, development studies, and financial risk management. Its complexity is amplified by the diverse terminologies and overlapping frameworks used across academic, policy, and industry circles. Terms such as "green finance", "responsible investment", "climate finance", "impact finance", and "ESG finance" are often used interchangeably, although they may differ in their objectives, mechanisms, and evaluative criteria (Boffo & Patalano, 2020).

At its core, sustainable finance seeks to reconcile the traditional objectives of financial performance with broader societal and environmental goals. This reconciliation is operationalized through the incorporation of ESG features into "investment analysis", lending practices, and corporate reporting frameworks. While environmental factors relate to issues such as carbon emissions, water use, and biodiversity impact, social features incorporate "labor practices", "human rights", and "community engagement". Elements of governance, on the other hand, refer to "board structure", "executive compensation", "transparency", and "shareholder rights" (Friede et al., 2015).

Given its broad scope, sustainable finance has attracted the attention of an extensive variety of "stakeholders"—academics, policymakers, "financial institutions", Non-Governmental

Organizations (NGOs), and rating agencies—each contributing to its evolving discourse. However, this diversity also introduces fragmentation and conceptual ambiguity, making it challenging to synthesize insights and develop cohesive theoretical frameworks. Thus, a bibliometric review is well-positioned to provide much-needed clarity and structure to this dynamic and expanding field.

1.2 Stakeholders' relevance of sustainable finance

The urgency to mobilize capital for sustainability purposes has placed sustainable finance at the forefront of global policy agendas. The European Union's Sustainable Finance Action Plan in 2018, "the Network for Greening the Financial System (NGFS)", and "the Task Force on Climate-related Financial Disclosures (TCFD)" are just a few examples of coordinated efforts aimed at integrating sustainability into financial regulation and decision-making. These policy developments have in turn catalyzed scholarly investigation into the implications of "sustainable finance" for "financial stability", regulatory frameworks, and long-term value creation (Campiglio et al., 2018).

Simultaneously, the investment community has witnessed a significant inflow of capital into ESG-themed funds, green bonds, and social impact instruments. Global sustainable fund assets surpassed $2.7 trillion by the end of 2021, indicating the mainstreaming of ESG criteria in investment strategies (Morningstar, 2022). These trends underscore the growing consensus that financial markets can—and should—play a vital role in achieving sustainability outcomes.

Financial institutions—including banks, asset managers, and insurance companies—are the operational backbone of sustainable finance. They mobilize capital for projects aligned with ESG principles, develop sustainable investment products, and integrate ESG risk assessments into lending and investment decisions. By shifting capital allocation towards sustainable sectors, they act as a bridge between policy objectives and tangible economic impact (Simeonovski et al., 2025).

NGOs serve as watchdogs, advocates, and innovators in the sustainable finance ecosystem. They influence corporate and investor behavior by highlighting sustainability risks, advocating for stronger ESG commitments, and facilitating multi-stakeholder dialogues. NGOs often push the boundaries of what constitutes best practice, ensuring that sustainable finance moves beyond compliance toward genuine impact.

Rating agencies provide the evaluative infrastructure necessary for market trust. Through ESG ratings, sustainability indices, and credit risk assessments, they guide investors in distinguishing between credible sustainable investments and those that merely adopt superficial ESG language. Their methodologies influence capital flows and incentivize companies to improve their sustainability performance (Aggarwal et al., 2024; Fu et al., 2023).

Despite this momentum, several critical questions remain unanswered: 1. "How has the domain evolved over time", and what are its emerging frontiers? 2. What are the dominant themes in "sustainable finance research?" 3. "Which scholars, nations, documents, and sources are leading the field?" 4. "What is the overarching structure of the literature on sustainable finance?" These are some of the questions that this bibliometric review seeks to address.

By answering these questions, the review will offer a panoramic yet nuanced view of the sustainable finance research landscape, serving as an important resource for academics, "policymakers", and "practitioners" alike.

The rest of the manuscript is prepared as follows: Section 2 presents the material and methods, as well as data sources, bibliometric tools, and analytical procedures. Section 3 discourses the results of the bibliometric analysis, including performance metrics, collaboration networks, thematic structures, and implications of the findings. Section 4 concludes the paper with significant understandings, limitations, and recommendations for forthcoming research.

2. Materials and methods

To run a "bibliometric analysis" on "sustainable finance literature", the study employed methodologies such as citation analysis, "co-occurrence analysis", and "co-citation analysis"

(Cisneros et al., 2018; Eck & Waltman, 2010). VOSviewer software was selected for its superior versatility compared to other available tools (Eck & Waltman, 2010).

2.1. Data sources

Mongeon and Paul-Hus (2016) and Hallinger and Kovačević (2019) both support the selection of Scopus as the data source, citing its comprehensive coverage of "social science" literature compared to the "Web of Science". While the Web of Science is recognized for its "higher-quality journals" due to its more selective indexing, this claim requires empirical validation. To justify the use of Scopus, the authors referenced Archambault et al. (2009), whose study on multidisciplinary research revealed a strong connection amid the publications and citations indexed in "Scopus" and those in the "Web of Science".

2.2. Search criteria

The exploration for relevant articles commenced on April 18, 2025, using "the Scopus database" and a predefined exploration string. To refine the selection, we used the inclusion and exclusion standards outlined by the "Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA)" guidelines (Moher et al., 2009). Following the four-step process illustrated in Figure 1, a total of 419 manuscripts were considered appropriate for participation in our evaluation and bibliometric analysis.

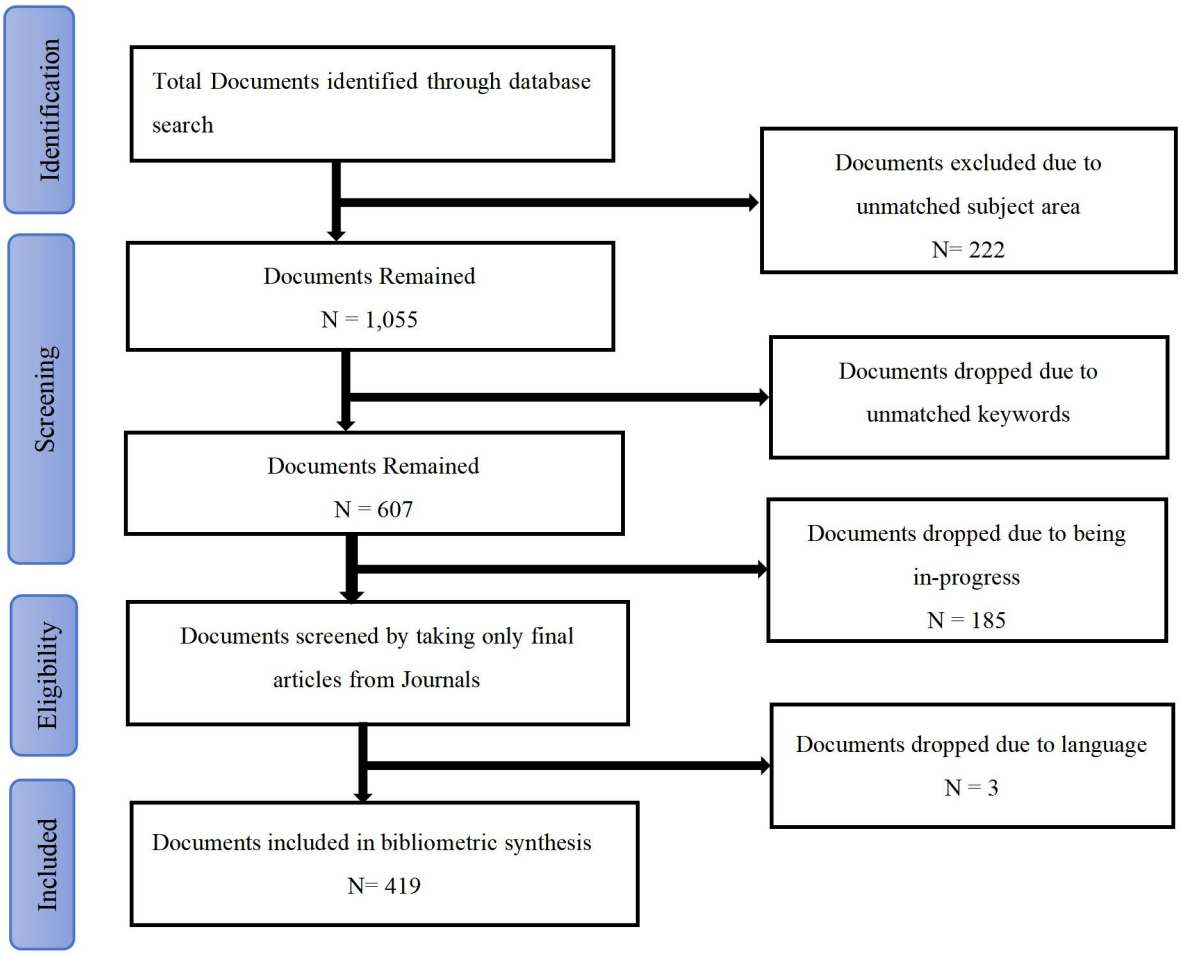

Figure 1. The PRISMA flow diagram explaining steps in data identification and screening (Moher et al., 2009)

This "evidence-based" minimum framework was created to assist writers in presenting a broad range of "methodical and meta-analyses", which are commonly utilized to evaluate the benefits and drawbacks of medical interventions. PRISMA is designed to promote comprehensive and transparent reporting by authors (Gough et al., 2012) and was adapted for this social sciences

study to ensure clarity and openness. To enhance the accuracy of the search, parentheses are used for grouping, Boolean operators "OR" and "AND" help manage term inclusion or exclusion, and wildcard characters "?" and "*" support flexible search integration.

The Scopus search using the search string ("sustainable digit* financ*" OR "green digit* financ*" OR "eco-friendly digit* financ*" OR "Sustainab* fintech" OR "digit* green financ*" OR "responsibl* digit* financ*" OR "Sustainable finance* technolog*" OR "ESG-aligned digit* financ*" OR "sustainable financ* technolog*" OR "digit* sustainable invest*" OR "impact-driven digit* financ*" OR "climate-cons* digit* finance" OR "digita*ESG financ*" OR "green fintech" OR "ethical digit* financ*") yielded 1,277 documents. After screening for the relevance of the documents, 858 were removed, leaving 419 for the final analysis (Figure 1).

3. Results

Data from 419 publications—as well as "authors, titles, abstracts, keywords, and citation information"—was extracted for subsequent investigation. Bibliometric investigations were conducted using VOSviewer in conjunction with "Excel and Scopus analytical tools". These analyses encompassed "author co-citation", "keyword co-occurrence", "co-citation", "citation analysis", and the "visualization of bibliometric" relationships (Eck & Waltman, 2017; Priyan et al., 2023). This work provides understanding into the evolution of the "sustainable finance literature" since 2019. The research questions formulated guided a deeper understanding of the field's progression and its underlying changing aspects.

3.1 Descriptive analysis for evolution of sustainable finance

The section aims to comprehensively address question number one, which explores, "How has the domain evolved over time?" and "What are its emerging frontiers?" The results reveal a clear inclination in the development and growth of the sustainable finance knowledge base. Research output in this field, based on documents indexed in the Scopus database, began in 2019 with a single publication. Growth remained modest over the next two years (2020 and 2021), likely due to the disruptive influence of "the COVID-19 pandemic". However, a notable increase in publications emerged in 2022, culminating in a sharp rise in 2024, which saw a peak of 175 publications (Figure 2). In 2025, the upward trajectory appears to be continuing; as of the data collection phase for this study, 78 documents had already been published within the first four months of the year. This suggests that publication output is expected to surpass previous years. To comprehensively address Research Question 1—"What is the current trend in research related to sustainable finance?"—additional insights are exhibited in Table 1 and Figure 2.

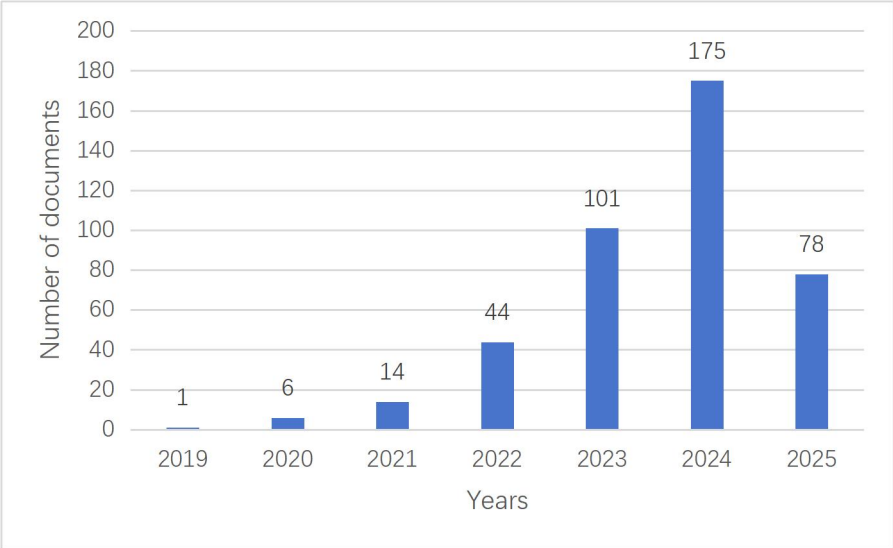

Figure 2. Research Growth Trajectory

Table 1. The Keywords Growth Trajectory in Sustainable Finance Literature

ID	Label	X	Y	Cluster	TLS	OCC	APY
1	Fintech ecosystem	-0.0429	0.02	4	419	215	2023.502
2	Financial inclusion	-0.3329	-0.3115	5	144	68	2023.309
3	Green digital finance	0.4558	-0.1169	2	92	49	2023.837
4	Sustainability	-0.1287	0.1559	1	107	40	2023.425
5	Sustainable development	0.2086	0.0405	3	89	39	2023.615
6	Digital finance empowerment	0.2635	-0.1762	2	70	37	2023.595
7	Sustainable development goals	-0.1299	-0.1116	5	76	31	2023.419
8	ESG investments	-0.1022	-0.4708	7	56	27	2024.037
9	Digital financial inclusion	-0.3068	-0.2013	4	44	25	2023.8
10	Digital technologies	-0.3878	0.1895	6	61	25	2023.6
11	Carbon emission efficiency	0.4749	-0.2967	2	46	21	2023.905
12	Green innovations	0.366	-0.7739	7	41	21	2023.952
13	Digitalization	0.3558	0.1426	2	32	17	2023.353
14	Financial exclusion	0.206	-0.7323	7	28	17	2023.765
15	Natural resources	0.9554	-0.2886	3	41	16	2023.938
16	Blockchain technology	0.2803	0.6782	1	34	15	2023.467
17	Environmental sustainability	0.7255	-0.4469	3	36	15	2024
18	Economic sustainability	0.0747	-0.2688	3	37	14	2023.214
19	Financial performance	-0.0404	-0.7089	7	33	14	2022.571
20	Sustainable financing	0.5674	0.4305	2	35	14	2023.929
21	Financial advancement	0.3962	-0.5485	7	30	13	2023.539
22	Innovation performance	0.1815	0.2634	1	34	13	2023.385
23	Renewable energy consumption	0.8883	-0.578	3	30	13	2023.462
24	Small business enterprises	-0.7127	-0.3195	5	30	13	2023.385
25	Electronic payment infrastructure	-0.4751	-0.3378	4	32	12	2023.75

Legend: TLS = Total link strength; OCC = Occurrences; APY = Average publication per year

To enhance understanding of the domain's growth, the overall "timeframe" was segmented into two intervals, and the frequency of co-words within an individual period was standardized against the total number of co-words. This approach enabled a systematic analysis of the temporal evolution of the sustainable finance domain and facilitated the identification of emerging trends (Agramunt et al., 2020; Priyan et al., 2023).

Table 1 presents the evolution of keywords across the whole study period along with within the two defined "sub-periods". The initial "sub-period", spanning from 2019 to 2022, is regarded as the foundational phase, characterized by an average of approximately sixteen publications per year. During this phase, the five most frequently co-occurring keywords—"fintech ecosystem", "financial inclusion", "digital financial inclusion", "sustainability", and "financial performance"—accounted for approximately 40 percent of all co-word occurrences.

The period 2023 - 2025 is identified as the "take-off phase", marked by a steady growth in documents published, with an average of more than 120 papers published annually. The five most frequently occurring terms during this phase were "fintech ecosystem", "financial inclusion", "green digital finance", "sustainable development", and "sustainability", collectively accounting for about 39 percent of all keyword occurrences. This period also witnessed the emergence of several prominent themes, including "digital finance empowerment", "ESG investments", "digital

technologies", "green innovation", "carbon emission efficiency", "environmental sustainability", and "innovation performance". These keywords have emerged as current focal points in academic research. Given their novelty, future studies are encouraged to examine them as variables in relation to sustainable finance. For instance, the urgency to mobilize capital for sustainability purposes has placed sustainable finance at the forefront of global policy agendas. The "European Union's Sustainable Finance Action Plan in 2018", "the Network for Greening the Financial System", and "the Task Force on Climate-related Financial Disclosures" are just a few examples of coordinated efforts aimed at integrating sustainability into financial regulation and "decision-making" (Campiglio et al., 2018). These policy developments have in turn catalyzed scholarly inquiry into the implications of sustainable finance for financial stability, regulatory frameworks, and long-term value creation (Campiglio et al., 2018).

3.2 Thematic analysis of keywords in "sustainable finance" research

The section aims to comprehensively address question number two, which explores: What are the dominant themes in "sustainable finance research"? To analyze the keywords, "VOSviewer" was utilized to measure the incidence and relationships between co-words in publications from 2019 to 2025. By establishing a threshold requiring a keyword to appear in at least five documents, the quantity of keywords was reduced from 784 to 98, and a further 26 keywords were removed due to not being for the theme strength, such as "China, regression, literature review, the US, and Asia, among them (Figure 3).

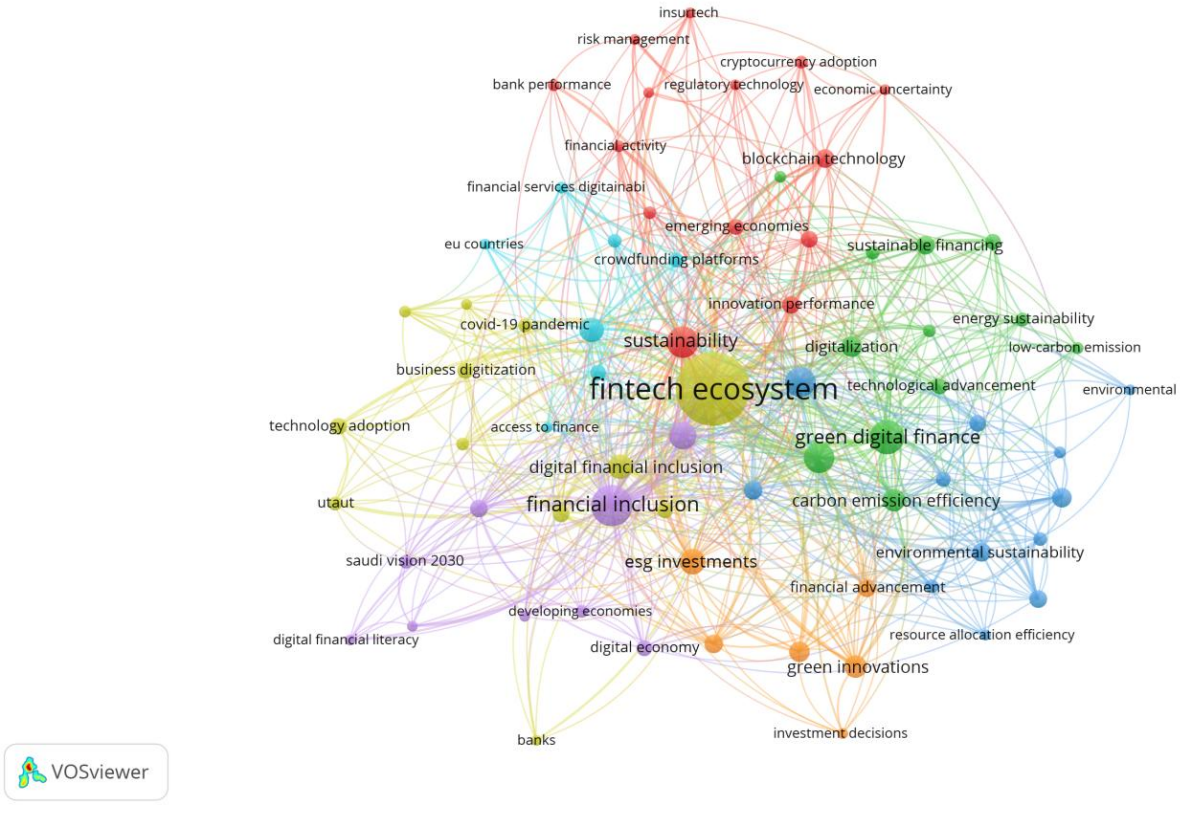

Figure 3. Co-occurrences showing the overall keywords growth at min 5, n= 72

Therefore, the 72 keywords form the network map for the sustainable digital finance literature (Eck & Waltman, 2017; Priyan et al., 2023). Identifying the most frequently discussed topics related to sustainable finance is essential for achieving the objectives outlined in this study. Table 1 and the map (Figure 3) displayed a large central node for "Fintech ecosystem", indicating its role as the key term connecting other keywords. This visualization also illustrated the supply of keywords across papers based on their publication dates.

A keyword analysis was performed to examine the key topics discussed in the sustainable digital finance literature. VOSviewer software was used to identify the most frequently occurring terms at the beginning of the study.

The co-occurrence analysis of author keywords in sustainable finance research reveals a dynamic and evolving knowledge base, with distinct thematic concentrations and emerging research trajectories. At the core of the intellectual structure are high-frequency terms such as "*fintech ecosystem*", "*financial inclusion*", "*green digital finance*", "*sustainability*", and "*sustainable development*", These keywords occupy central positions in the X-Y spatial layout, suggesting their integrative role in connecting various thematic clusters. For example, "fintech ecosystem" lies almost at the center of the coordinate plane (X = -0.04, Y = 0.02), highlighting its broad relevance across multiple areas of sustainable finance. This centrality underscores how digital technologies are becoming instrumental in driving financial inclusion and environmental outcomes.

The thematic structure divides clearly into a few dominant clusters. One key grouping is centered around green and environmental finance, comprising keywords such as "*green digital finance*", "*carbon emission efficiency*", "*green economic growth*", "*climate change mitigation*", and "*energy transition*". These keywords, generally located on the right side of the X-axis, reflect a research trend oriented toward environmental sustainability and climate-related financial innovation. Their relatively recent average publication years (mostly post-2023) and moderate to high citation scores suggest a growing scholarly and policy interest in climate finance mechanisms and the integration of green investment strategies into mainstream finance.

Another major theme is technological and digital transformation in finance. Keywords like "*digital financial inclusion*", "*blockchain technology*", "*industry 4.0 technology*", "*artificial intelligence*", and "*digital finance empowerment*" represent this trend. These are positioned in the upper quadrants of the map, revealing their forward-looking orientation and association with innovation-driven sustainable finance. The keyword "artificial intelligence", for example, not only has a strong normalized citation score (2.01) but also lies within a zone reflecting emergent but influential scholarship. This indicates a rising focus on how advanced technologies can optimize ESG compliance, automate risk evaluation, and enable better transparency in financial systems.

Socially inclusive finance also features prominently, particularly through terms such as "*financial inclusion*", "*financial exclusion*", "*women's economic empowerment*", and "*small business enterprises*". These keywords, mostly located in the left and lower quadrants, point to a foundational discourse around equity and access in financial systems. While these topics have slightly lower citation averages compared to technology-oriented terms, they remain essential in shaping the inclusive growth narrative within sustainable finance. Additionally, keywords like "*digital financial services*", "*electronic payment infrastructure*", and "*mobile money services*" underscore the critical role of digital financial infrastructure, particularly in developing economies where these technologies serve as key enablers of inclusion.

A closer look at temporal trends reveals that most dominant keywords have emerged or gained prominence in recent years, particularly between 2023 and 2024. For instance, "*green digital finance*", "*digital financial inclusion*", "*ESG investments*", and "*green economic growth*" all show average publication years of 2023 or later, indicating a recent acceleration in research interest. This surge aligns with global regulatory shifts, such as the implementation of the EU taxonomy, increased climate risk disclosure standards, and the growing traction of net-zero commitments. Even relatively specialized terms such as "*climate change mitigation*", "*renewable energy consumption*", and "*circular economy*" are gaining momentum, as reflected in their citation impact and spatial centrality.

Peripheral or niche themes also provide insight into emerging areas of interest. Terms such as "*cryptocurrency adoption*", "*regulatory technology*", "*internet of things*", and "*insurtech*" appear on the outer edges of the map, representing exploratory work that intersects digital innovation and sustainability. Despite lower occurrence frequencies, some of these terms (e.g., "business digitization" and "access to finance") show notably high average citations, indicating that they are early but influential contributors to future discourse. Likewise, keywords like "*technological*

advancement", "*economic sustainability*", and "*circular economy*" not only have high normalized citation scores but also bridge environmental and technological priorities, pointing toward an interdisciplinary expansion of the field.

3.3 Investigation of the fruitful "authors", "countries", and "sources"

The section aims to comprehensively address question number three, which explores: "Who are the most influential authors, countries, and sources in the field of sustainable finance?" The response to this query offers valuable insights into the key contributions made by countries, academic sources, scholars, and their publications within the domain of sustainable finance.

3.3.1 Investigation of the fruitful authors in sustainable finance

This study offers insights into the participation of individual scholars and their scholarly work in the sustainable finance field. Table 2 highlights the most dominant authors in sustainable finance, ranked according to their citation counts in sustainable finance-related publications they have received. The h-index was excluded from consideration, as "the Scopus h-index" reflects a writer's overall academic yield, which extends outside the scope of sustainable finance (Priyan et al., 2023). Notably, all citation counts presented in Table 2 are exclusively based on publications related to sustainable finance.

Table 2. Most fruitful authors in sustainable finance literature

ID	Author	Documents	Citations
1	Al-Okaily, Manaf	9	434
2	Arner, Douglas W.	1	366
3	Buckley, Ross P.	1	366
4	Veidt, Robin	1	366
5	Zetzsche, Dirk A.	1	366
6	Hsu, Yen	1	334
7	Liu, Yang	1	334
8	Luan, Lin	1	334
9	Wu, Weilong	1	334
10	Zhang, Zhiqiang	1	334
11	Pizzi, Simone	2	300
12	Tao, Ran	2	270
13	Naqvi, Bushra	1	268
14	Rizvi, Syed Kumail Abbas	1	268
15	Su, Chi-Wei	1	268

The number of documents an author has is one of the factors for a high citation count. As shown in Table 2, Al-Okaily, Manaf leads in citation count with nine publications. In this case, there is a correlation amid the number of manuscripts an author has and the citation counts received. However, the number of articles is not the only factor because most of the authors have a single document, but there is a slight difference for Al-Okaily, Manaf, who has nine documents.

3.3.2 Analysis of the productive and fruitful countries in the sustainable finance domain

An analysis was conducted to identify the most influential nations based on their volume of published documents and citation count. The study encompassed a total of 87 countries. Figure 4 highlights the top 10 most productive nations in this regard. China ranked first with 170 publications, followed by India with 38 documents. The third country was Malaysia with 37 publications, followed by Saudi Arabia and the United Kingdom, who both had 30 publications each (Figure 4).

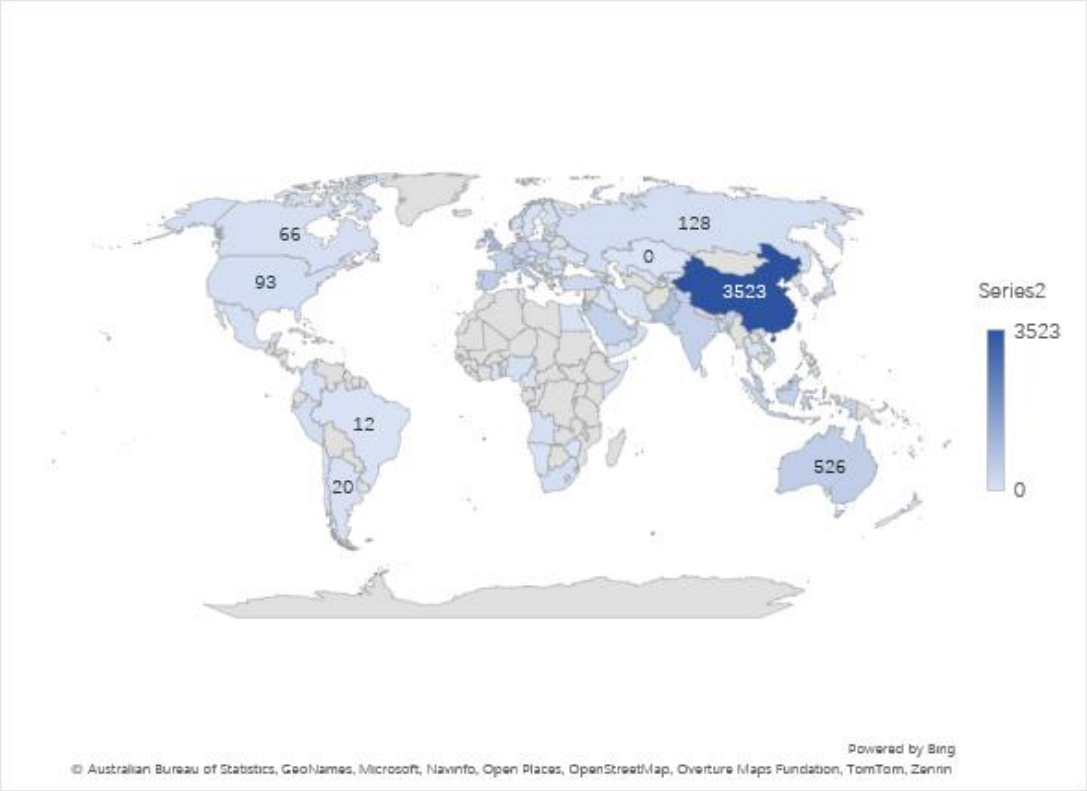

Figure 4. Most productive countries in sustainable digital finance literature

This suggests that research on sustainable finance is predominantly concentrated in developed European and Asian economies, with developing countries significantly under-represented (Figure 4). On the other hand, China with 3,523 citations, leads the top 15 prolific nations, followed by the United Kingdom, which had 1,111 citations. Additional countries and their corresponding citation counts are presented in Table 3, all of which are from Asia and Europe. This indicates a lack of participation from underdeveloped regions in other parts of the world. However, this absence does not imply that developing countries are in a favorable position. On the contrary, the implementation of sustainable finance policies remains particularly challenging in these nations, often due to low levels of technological adoption (Rwezimula et al., 2025), and understanding of such policies remains limited. Therefore, the effects of sustainable finance may vary substantially amid industrialized and undeveloped regions. Currently, the specific ways in which sustainable finance contributes to the economic advancement of undeveloped nations remain insufficiently understood. This represents a critical gap for forthcoming research, given that these nations play an essential role in driving their own economic growth, which in turn has global implications (Priyan et al., 2023).

Table 3. Most prolific countries in the sustainable digital finance literature

ID	Label	Documents	Citations
1	China	170	3523
2	United Kingdom	30	1111
3	Pakistan	24	784
4	Italy	19	712
5	Jordan	24	632
6	Malaysia	37	591
7	Spain	10	547
8	Taiwan	10	543
9	Australia	13	526
10	France	13	452
11	India	38	439
12	Saudi Arabia	30	430
13	Hong Kong	6	418
14	Germany	7	415
15	Indonesia	15	408

3.3.3 The topmost fruitful journals for sustainable finance literature

This method of evaluating source significance is based on the premise that greater influence is typically attributed to the most frequently cited and published works (Munodei & Sibindi, 2023; Rwezimula et al., 2025). The key sources are clearly illustrated in Tables 4 and 5.

Table 4. Most fruitful sources in sustainable digital finance literature

ID	Label	Documents	Citations
1	Sustainability (Switzerland)	67	1432
2	Resources policy	57	981
3	Journal of cleaner production	12	602
4	Energy economics	14	575
5	International review of financial analysis	5	433
6	Technological forecasting and social change	8	371
7	European business organization law review	1	366
8	Journal of open innovation: technology, market, and complexity	9	290
9	Journal of risk and financial management	9	193
10	International journal of information management	1	189
11	Journal of business research	1	166
12	Journal of financial reporting and accounting	2	123
13	Financial innovation	8	120
14	Finance research letters	14	111
15	Electronic commerce research	4	105

Table 5. Most productive sources in sustainable digital finance literature

ID	Label	Documents	Citations
1	Sustainability (Switzerland)	67	1432
2	Resources policy	57	981
3	Energy economics	14	575
4	Finance research letters	14	111
5	Journal of cleaner production	12	602
6	Research in international business and finance	12	70
7	International review of economics and finance	10	88
8	Journal of open innovation: technology, market, and complexity	9	290
9	Journal of risk and financial management	9	193
10	Financial innovation	8	120
11	Technological forecasting and social change	8	371
12	International review of financial analysis	5	433
13	Discover sustainability	4	1
14	Electronic commerce research	4	105
15	International journal of energy economics and policy	4	9

The analysis of journals within the research domain reveals a clear stratification in terms of productivity, influence, and thematic clustering. Notably, *Sustainability* (*Switzerland*) emerges as the dominant journal with the highest number of publications (67) and citations (1432), positioning it as a central hub in sustainability and environmental research. This is supported by its location in the positive X and Y quadrant, indicating close thematic ties to other prominent journals in related fields (Table 4).

Other journals such as *Resources Policy* and *Energy Economics* also demonstrate strong publication and citation figures, reflecting their importance in resource management and economic studies related to energy. These journals cluster tightly together, highlighting a network of closely linked research outlets focusing on environmental economics and policy. Journals like *Journal of Cleaner Production and International Review of Financial Analysis* show somewhat lower document counts but maintain a high citation impact, suggesting the publication of highly influential work despite lower output.

A considerable number of journals have zero or very low total link strength, indicating limited co-citation or collaboration links within this bibliometric network. This may reflect their niche focus, newer entry into the field, or lesser integration with broader research themes. For example, many specialized journals with recent average publication years—some as recent as 2024 or 2025—are positioned on the periphery of the map, suggesting emerging areas of study that have yet to establish strong citation networks.

The spatial coordinates further illustrate thematic separations among journals. Journals clustered in the positive X and Y coordinates tend to be related to sustainability, business research, and innovation, while those in the negative X region often correspond to finance, economics, or policy-related journals. This spatial differentiation suggests that research dissemination occurs in relatively distinct thematic communities, though some journals act as bridges linking these clusters.

Temporal analysis shows that most journals have very recent average publication years, predominantly between 2022 and 2024, signaling an actively evolving field with ongoing research and publication activity. Some older journals, with average years around 2020-2021, might represent more established outlets that have laid foundational work for current studies.

Therefore, more than 77% of citations were generated by just 10% of the sources—the top 15 journals—revealing a concentration of scholarly influence among a few dominant outlets (Table 4).

Interestingly, while the most productive journals were also the most cited, a journal with only a single publication still secured the seventh position among the top 15 most cited, surpassing others with over ten documents. This highlights that although the number of publications contributes to citation frequency, it is not the sole determinant of impact. Conversely, 20% of journals received no citations at all, with 99% of those publishing only a single document—suggesting that limited output may hinder visibility and citation potential. As journals play a critical role in disseminating knowledge, low publication volume may indicate a lack of commitment to that mission. However, considering the field's infancy, many journals may still be in their formative stages, struggling to gain recognition and scholarly traction. To enhance their impact and attract more citations, journals must focus on consistent publication, uphold academic integrity, and build trust within the research community.

3.4 Intellectual structure of the sustainable finance literature

The section aims to comprehensively address question four, which seeks to explore: "What is the overarching structure of the literature on sustainable finance?" Documenting research collaborations through co-citation analysis in a bibliometric review is essential for researchers, as it uncovers the intellectual framework and relationships within a given research area. By analyzing which authors or publications are commonly cited together, co-citation analysis identifies influential research groups, leading contributors, and developing collaborative networks (White & Griffith, 1981). Such analysis allows researchers to comprehend the progression of knowledge, follow the trajectory of key ideas, and pinpoint prospective collaborators, ultimately strengthening the field's consistency, recognition, and scholarly impact (Donthu et al., 2021).

Scientific mapping was applied to examine the "structure", which comprises the primary "theoretical and empirical" directions that define a specific academic field (Nerur et al., 2008). As a result, a network visualization was generated using "VOSviewer" to illustrate the "conceptual framework" of the "sustainable finance literature", derived through "co-citation analysis". Scholars utilizing co-citation analysis have observed that writers frequently quoted together typically share similar academic perspectives (Hallinger & Kovačević, 2019; Priyan et al., 2023).

"VOSviewer software" is capable of generating a system map that emphasizes the common features among authors cited within a specific database (Eck & Waltman, 2017). In the co-citation map produced for this study on "sustainable finance", the software identified 38,817 co-cited scholars. Among them, 486 received at least 20 co-citations (Figure 5). In the map, larger nodes indicate the most frequently cited researchers, while clusters distinguished by colors categorize authors into different research themes according to their relationships.

The top co-cited scholars—such as *Wang Y., Zhang Y., Buckley R.P., Arner D.W.,* and *Li Y.*—form the core of the knowledge base, as reflected by their extremely high citation counts and total link strengths. *Wang Y.,* for instance, stands as the most influential figure with 254 citations and the highest total link strength (20,139), positioned centrally in the network (X = -0.22, Y = -0.37), reflecting deep integration across topics in the field. Similarly, *Zhang Y.* and *Li Y.,* closely co-located with Wang, further reinforce the dominance of Chinese scholars and the centrality of Asia-focused research in sustainable finance discourse.

The spatial distribution of authors by cluster reveals three major intellectual traditions shaping the field. The first and most dominant cluster (Cluster 1) is composed of East Asian scholars with a strong emphasis on digital finance, financial inclusion, and green development. Authors in this cluster, such as *Li J., Wang J., Zhang X., Liu Y.,* and *Lee C.C.*, are concentrated in the left and lower quadrants of the map, suggesting a tightly interconnected scholarly group focusing on foundational issues in digital and inclusive finance. The density of their citations (often between 100 and 200) and strong link weights indicate these authors are frequently referenced together, signifying shared conceptual frameworks and methodological commonalities.

In contrast, Cluster 2 comprises mostly Western scholars—including *Buckley R.P., Arner D.W., Zetzsche D.A.*, and *Veidt R.*—who are primarily positioned in the right quadrant (e.g., Buckley at X = 0.83, Arner at X = 0.81), denoting their association with global financial law, digital regulation, and policy frameworks. These authors are heavily cited (each over 170 citations) and form a

transnational node that connects legal-financial scholarship with sustainable development and fintech regulation. Their location away from the central Cluster 1 group implies a conceptual boundary between regional economic development models (Cluster 1) and regulatory-financial architectures (Cluster 2).

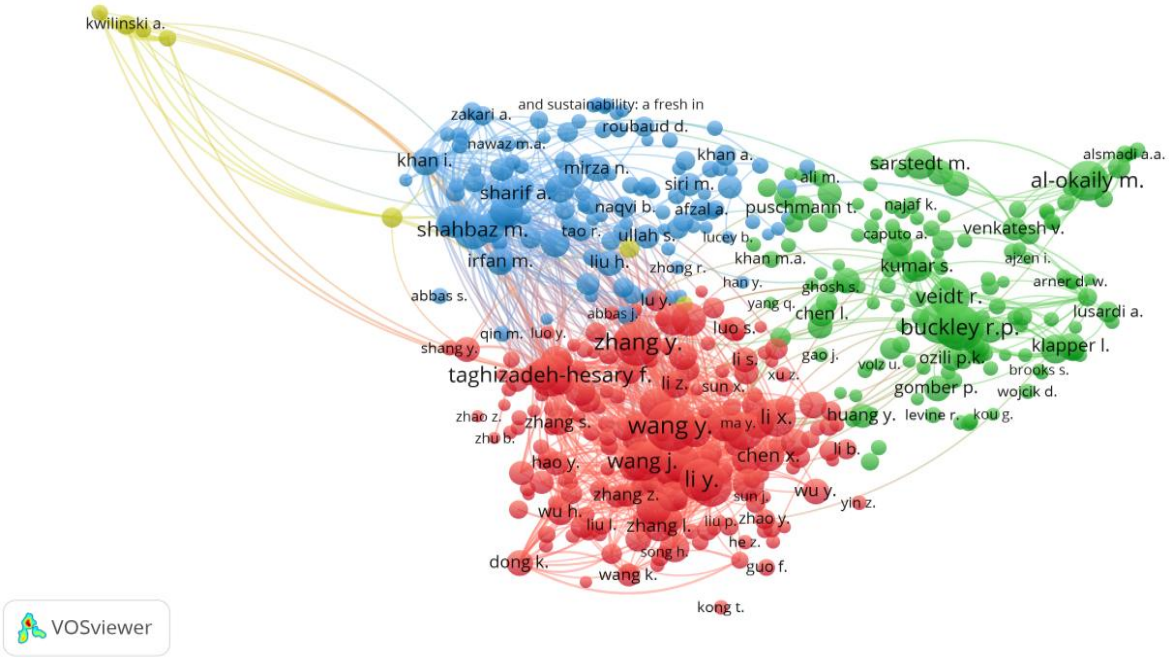

Figure 5. Co-citations analysis showing intellectual structure in sustainable finance, min 20, n=486

A smaller but distinct Cluster 3 includes authors such as *Shahbaz M., Razzaq A.,* and *Umar M.,* who tend to work on the intersection of sustainable finance and environmental economics. Their co-citation patterns suggest a strong focus on empirical econometrics, carbon emissions, and macroeconomic sustainability indicators. Though their citation counts are comparatively moderate (around 120–150), their spatial placement (far left or right edges) indicates specialization and potentially underutilized insights in broader sustainable finance discussions. *Shahbaz,* for instance, positioned at X = -0.93, Y = 0.36, appears as a bridge between financial sustainability and environmental modeling.

Interestingly, many of the highly co-cited authors cluster in the lower Y-axis range (negative Y-values), such as *Li J.* (Y = -0.59), *Liu Y.* (Y = -0.51), and *Lee C.C.* (Y = -0.67), which may imply their strong association with quantitative modeling, impact evaluation, and digital inclusion metrics—areas foundational to early research in sustainable finance. Meanwhile, authors appearing in higher Y-regions like *Al-Okaily M.* (X = 1.28, Y = 0.54) suggest more recent or peripheral thematic linkages, possibly in firm-level finance or institutional studies.

What stands out is the overall coherence and connectivity within the network, as seen in the uniformly high link strength values. Many authors such as *Li X., Wang Q.,* and *Chen Y.*—while slightly lower in citation count—still exhibit total link strengths over 9,000, indicating consistent co-citation with more influential authors and reinforcing the cumulative nature of scholarship in the field. Other co-cited authors among the top twenty-five can be seen in Table 6, and the clustered theme with their respective colors can be seen in figure 5.

Table 6. Co-citations analysis showing intellectual structure in sustainable finance

ID	Label	X	Y	Cluster	TLS	Citations
1	Wang Y.	-0.2151	-0.37	1	20139	254
2	Zhang Y.	-0.3363	-0.0599	1	17712	218
3	Buckley R.P.	0.8262	-0.0029	2	9999	212
4	Arner D.W.	0.8091	0.0018	2	10042	210
5	Li Y.	-0.1049	-0.5704	1	14778	191
6	Taghizadeh-Hesary F.	-0.6493	-0.1814	1	13004	185
7	Zetzsche D.A.	0.7518	0.0134	2	8775	179
8	Li J.	-0.074	-0.5943	1	13744	177
9	Al-Okaily M.	1.2837	0.5435	2	7341	171
10	Wang J.	-0.3191	-0.5017	1	13311	167
11	Veidt R.	0.7851	0.1106	2	7748	162
12	Liu Y.	-0.1794	-0.5067	1	12086	156
13	Li X.	0.1649	-0.3399	1	12401	154
14	Zhang X.	0.0475	-0.3903	1	11421	152
15	Shahbaz M.	-0.9328	0.3575	3	13767	148
16	Wang X.	-0.0181	-0.3592	1	11157	143
17	Lee C.C.	-0.2785	-0.6727	1	11237	127
18	Zhang J.	-0.1537	0.0296	1	10666	125
19	Razzaq A.	-0.9921	0.3927	3	11366	122
20	Wang Q.	-0.2882	-0.4893	1	10419	120
21	Sun Y.	-0.2095	0.0298	1	8878	114
22	Umar M.	-0.8098	0.4296	3	10529	114
23	Chen Y.	-0.6753	-0.1773	1	9601	110
24	Zhao J.	-0.1306	-0.3888	1	8267	108
25	Liu X.	-0.2691	-0.2878	1	9226	107

Legend: TLS = Total link strength

4. Conclusion, research gap, limitations, and direction for future studies

4.1 Conclusion

"Sustainable finance" has emerged as a transformative paradigm in global financial systems, intertwining economic decision-making with environmental and social considerations. This bibliometric review aimed to systematically map the intellectual structure, thematic development, and research trends within the domain of sustainable finance. By analyzing scholarly output over the past seven years, this study provides critical insights into the evolution of the field, its key contributors, and the interconnections among core research themes.

The findings of this bibliometric review reveal that sustainable finance has evolved from a niche concern to a globally significant research domain, particularly over the past five years. The exponential increase in publications—rising from just one document in 2019 to a peak of 175 in 2024—demonstrates how rapidly the field is expanding. This growth reflects a broader recognition of the role finance must play in addressing environmental and social challenges, especially under the imperatives of the climate crisis and the transition toward green economies. The research landscape is dominated by a few influential countries, notably China and the United Kingdom, and is anchored by core journals such as *Sustainability* (*Switzerland*) and *Resources Policy*. Thematically,

the field is heavily centered on ESG factors, green bonds, climate finance, and sustainability performance, supported by a relatively concentrated group of highly cited authors and foundational references.

The results reveal that sustainable finance is a dynamic and interdisciplinary field, integrating elements from finance, economics, environmental science, management, and business management. The concept has moved beyond its early roots in socially responsible investing to encompass broader considerations such as ESG integration, climate risk, green financial instruments, and sustainable development. This diversification of topics reflects both the growing complexity of sustainability encounters and the expanding role of finance in solving them.

The intellectual base of sustainable finance is shaped by foundational theories such as stakeholder theory, institutional theory, and the resource-based view, with a growing emphasis on concepts like green innovation, and financial inclusion. Prominent authors and institutions from Europe, North America, and increasingly Asia have contributed significantly to the field's development, with an observable shift towards empirical and policy-relevant research.

Moreover, the rise of thematic areas such as fintech ecosystems, ESG investments, green digital finance, and sustainability suggests that sustainable finance is maturing into a well-defined scholarly domain. The bibliometric mapping of co-citation and keyword clusters illustrates the thematic richness of the field and highlights areas of convergence and divergence in scholarly dialogue.

Sustainable finance stands at the nexus of global efforts to achieve long-term environmental, social, and economic resilience. As the field continues to mature, academic research must keep pace with its complexity, diversity, and societal importance. This bibliometric review contributes to that goal by offering a structured and evidence-based overview of the knowledge base while highlighting key directions to guide future scholarly inquiry and policy engagement.

4.2 Research gaps

Current research in the domain of “sustainable finance” has mainly focused on subjects like “fintech ecosystem”, “financial inclusion”, “digital financial inclusion”, “sustainability”, and "sustainable development goals", among the other keywords in the current sub-period. As a result, these topics demand significant attention from scholars, since they remain relatively novel not only within developing nations, as demonstrated by the analysis, but also across many advanced economies (Tables 1 and 3).

4.3 Limitations

This study is not without limitations. The analysis is based solely on documents indexed in the Scopus database, which, while comprehensive, may exclude relevant contributions from other academic databases (“Web of Sciences”, “Google Scholar”, SSRN, or regional repositories), non-English sources, or gray literature such as policy papers and practitioner reports. Additionally, as the field is rapidly evolving, bibliometric indicators such as citation counts may not fully capture the influence of the most recent publications. Temporal lag in citations and database updates may also underrepresent current dynamics. Moreover, the reliance on keyword co-occurrence and citation metrics, though insightful, may overlook conceptual nuances and qualitative contributions to the discourse.

4.4 Directions for future research

Given the dynamic nature of “sustainable finance”, there are several promising directions for future academic inquiry:

Much of the current literature is dominated by studies from developed economies, particularly in Europe and Asia. Future research should broaden its focus to include case studies and empirical investigations from developing and emerging markets. These regions face exceptional encounters and prospects in “sustainable finance”, including weaker regulatory frameworks, different risk profiles, and heightened exposure to climate-related vulnerabilities.

There is growing concentration on measuring the actual effect of sustainable finance on environmental and social outcomes. Future studies should employ longitudinal designs, quasi-experimental methods, and causal inference techniques to evaluate whether ESG integration and green financial instruments lead to tangible improvements in sustainability performance. Rigorous impact assessments are essential for advancing the field credibility and legitimacy.

Digital innovation is reshaping sustainable finance in profound ways. Blockchain, artificial intelligence, big data analytics, and fintech solutions are increasingly used to enhance transparency, traceability, and efficiency in sustainable investments. Scholars should explore the intersection of digital finance and sustainability, examining how technology can address traditional barriers to impact investing, ESG assessment, and climate risk management.

Investor behavior in sustainable finance remains an underexplored area. There is a need to investigate how personal values, cognitive biases, social norms, and cultural contexts shape sustainable investment decisions. Behavioral finance perspectives can offer new understandings of motivations and limitations of market participants engaging with ESG issues.

Green bonds and ESG equity funds have received significant academic attention, but other instruments—such as sustainability-linked loans, impact funds, and carbon markets—remain relatively understudied. Sector-specific analyses, particularly in energy, transportation, agriculture, and real estate, can uncover contextual nuances and best practices.

Despite its vibrancy, several research gaps remain evident. First, while ESG and green finance dominate current scholarship, there is limited exploration of the socio-economic implications of sustainable finance in developing and marginalized economies. Concepts like just transition, indigenous finance practices, and local governance remain peripheral. Second, while methodological studies exist, there is a lack of longitudinal, multi-level analyses that connect sustainable finance performance to systemic financial stability or behavioral finance perspectives. Furthermore, sustainability metrics and impact measurement tools are still inconsistently applied or conceptually fragmented across the literature. These gaps underscore the need for more integrative and cross-disciplinary approaches that blend finance with insights from social sciences, development studies, and ecological economics.

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