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Green Bonds and Green Financing: A Bibliometric Analysis

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ABSTRACT

Green bonds and green financing have emerged as essential financial mechanisms supporting global sustainability transitions, particularly in addressing climate change, renewable energy development, and carbon reduction strategies. This study conducts a comprehensive bibliometric analysis of Scopus-indexed publications to map the intellectual structure, thematic evolution, and collaboration patterns within green finance research. Using VOSviewer, the analysis visualizes keyword co-occurrence, author networks, institutional affiliations, and country collaborations. The findings reveal that "green bonds," "green finance," "sustainable development," and "energy efficiency" are the field's dominant research hotspots. China, the United Kingdom, India, and Italy appear as central contributors, indicating strong cross-national engagement. Highly cited studies emphasize themes such as green bond premiums, market reaction, spillover effects, and green economic recovery. The results demonstrate that research has evolved from conceptual discussions on environmental finance toward applied empirical modeling and policy-relevant analysis. This study enriches the understanding of green bond literature and highlights opportunities for advancing interdisciplinary collaboration in sustainable finance scholarship.

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1. INTRODUCTION

The accelerating global concern over climate change, environmental degradation, and the depletion of natural resources has pushed governments, corporations, and financial institutions to adopt more sustainable economic models. One of the most significant financial innovations emerging from this global shift is the development of green bonds—a financing instrument dedicated to funding environmentally responsible projects such as renewable energy, clean transportation, energy-efficient infrastructure, and climate-resilient development [1]–[3]. Since their initial introduction by multilateral development banks, green bonds have rapidly evolved into a mainstream financial mechanism that bridges the gap between environmental goals and financial market expectations. Their increasing adoption reflects the growing demand for financial instruments that align profitability with sustainability, offering investors a path to contribute to global climate solutions while achieving stable returns [4]–[6].

Aligned with these transformations, the broader concept of green financing has also expanded, encompassing financial products and strategies that support the transition toward low-carbon, circular, and environmentally conscious economies. Green financing mechanisms have become strategic tools for addressing Sustainable Development Goals (SDGs), especially those related to affordable clean energy, sustainable cities, responsible consumption, and climate action [7]–[10]. As countries design national roadmaps for carbon neutrality, green financing instruments—including green loans, sustainability-linked funds, and environmental credit schemes—play a pivotal role in mobilizing private capital alongside public investment [11], [12]. This shift underscores the importance of integrating environmental considerations into financial decision-making and long-term economic planning.

In tandem with market expansion, scholarly interest in green bonds and green financing has grown substantially. Since 2015, academic publications on green finance have increased exponentially, reflecting a multidisciplinary research landscape involving finance, economics, environmental science, policy studies, and sustainability management. Scholars have explored various dimensions of green bonds, ranging from pricing behavior, risk premiums, spillover effects, investor preferences, and regulatory frameworks to the socioeconomic benefits of green-financed projects. Several highly cited studies have examined whether green bonds offer financial advantages (e.g., green premiums), the credibility of third-party verification, the interconnectedness between green financial assets, and the role of green financing in advancing energy efficiency and environmental responsibility [7], [12]–[15].

Despite this rapid growth, research on green bonds and green financing remains fragmented, with topics dispersed across numerous domains and exhibiting varying methodological approaches. The expansion of literature raises essential questions about the intellectual structure, evolution, collaboration patterns, and emerging thematic clusters within this field. A comprehensive understanding of these dynamics is crucial not only for academics but also for policymakers and practitioners seeking insights into how green finance is shaping global sustainability agendas. Mapping this field bibliographically provides clarity on the most influential works, dominant themes, leading countries, and evolving research trajectories—allowing scholars to identify research gaps and policymakers to adopt evidence-based strategies.

Given these developments, a bibliometric analysis offers a systematic and quantitative approach to explore the knowledge structure of green bonds and green financing. By examining patterns of citations, keyword co-occurrences, collaboration networks, and thematic trends, bibliometric mapping can illustrate how the field has developed, where scholarly attention is concentrated, and how research has shifted in response to global sustainability priorities. Such an approach also highlights influential authors, institutions, and countries that have shaped the discourse, enabling a clearer understanding of the global landscape of green finance research.

Therefore, this study aims to provide an in-depth bibliometric analysis of scholarly publications on green bonds and green financing indexed in Scopus. The purpose is to uncover research trends, visualize intellectual networks, identify the most cited works, and map the thematic evolution of the field. By doing so, this article contributes to the academic literature by offering a structured overview of the development, collaboration patterns, and emerging directions in green finance research. Ultimately, the findings are expected to support scholars, regulators, and practitioners in strengthening the role of green finance as a critical instrument for achieving sustainable economic transformation.

2. METHODS

This study adopts a bibliometric analysis approach to examine the intellectual structure, publication patterns, and evolving

research trends related to green bonds and green financing. Bibliometric methods provide a quantitative and systematic technique to map scientific literature, enabling researchers to identify influential publications, dominant themes, and collaboration networks across authors, affiliations, and countries. The use of bibliometric techniques is considered appropriate for fields experiencing rapid growth, as it allows for a comprehensive overview of how knowledge is produced, connected, and developed over time.

2.1 Data Source and Search Strategy

The dataset used in this study was retrieved from the Scopus database, which is widely recognized for its extensive coverage of peer-reviewed scientific publications across multidisciplinary fields. Scopus is preferred due to its robust indexing system, detailed citation data, and compatibility with bibliometric tools. To ensure the relevance of the dataset, the search terms were formulated using combinations related to the core themes of this study, including "green bonds," "green financing," "sustainable finance," and "environmental finance." Boolean operators such as AND, OR, and wildcard symbols were applied to capture variations of the terms.

The search was limited to journal articles to maintain scholarly quality and comparability. No geographical restrictions were applied, allowing for global representation of studies. The final dataset underwent a preliminary screening process to remove duplicated records, incomplete entries, and publications not aligned with the study's thematic focus. The resulting dataset formed the basis for bibliometric visualization and citation analysis.

2.2 Bibliometric Technique and Analytical Tools

This research employs two major analytical procedures: performance analysis and science mapping. Performance analysis focuses on metrics such as publication volume, citation counts, and highly influential documents. This includes the calculation of the most cited articles, key authors, prominent affiliations, and leading countries contributing to the field. Table 1 in the document reflects the outcome of this process by identifying the top-cited publications within the topic of green bonds and green financing.

Science mapping, on the other hand, visualizes the relationships among authors, keywords, affiliations, and countries to uncover structural patterns in the literature. In this study, VOSviewer, a widely used bibliometric visualization tool, was utilized to generate co-occurrence networks, overlay maps, density maps, and co-authorship networks. The software is capable of clustering related concepts, showing thematic evolution, and revealing collaborative linkages across global research communities.

The analyses conducted in this study include a keyword co-occurrence analysis to identify major research themes based on the frequency of keyword appearances, visualized through network, overlay, and density maps shown in Figures 1–3; a co-authorship analysis that reveals collaboration patterns among authors, institutions, and countries, illustrating the extent of scholarly interaction as presented in Figures 4–6; and a citation analysis that highlights the most influential studies based on citation counts and evaluates their intellectual impact within the field, with the top-cited documents summarized in Table 1.

2.3 Procedure of Data Cleaning and Standardization

Before constructing the bibliometric maps, a thorough data-cleaning process was conducted to ensure analytical accuracy, addressing several key issues such as variations in author names by correcting spelling differences and inconsistent initials to prevent fragmented author clusters; keyword standardization by harmonizing synonymous terms (e.g., "green bond" vs. "green bonds," "sustainable finance" vs. "sustainability finance"); affiliation normalization by consolidating institutions with multiple campus names or abbreviations under a single standardized entry; and duplicate checking to

remove redundant records that could inflate analytical counts. This standardization process ultimately strengthened the reliability of the bibliometric visualizations and enhanced the interpretability of the results.

2.4 Research Design and Interpretation Approach

The research design adopts a descriptive–quantitative approach typical of bibliometric studies, with interpretation carried out through cross-analysis of visual patterns in keyword clusters, geographic trends in country collaboration, citation influence from top-cited studies, and institutional networks shaping the field. This interpretive process integrates perspectives from social network theory, knowledge-diffusion concepts, and thematic-evolution frameworks commonly applied in bibliometric research, enabling the study to generate meaningful insights into the development of green bond and green financing literature.

3. RESULTS AND DISCUSSION

3.1 Keyword Network Structure

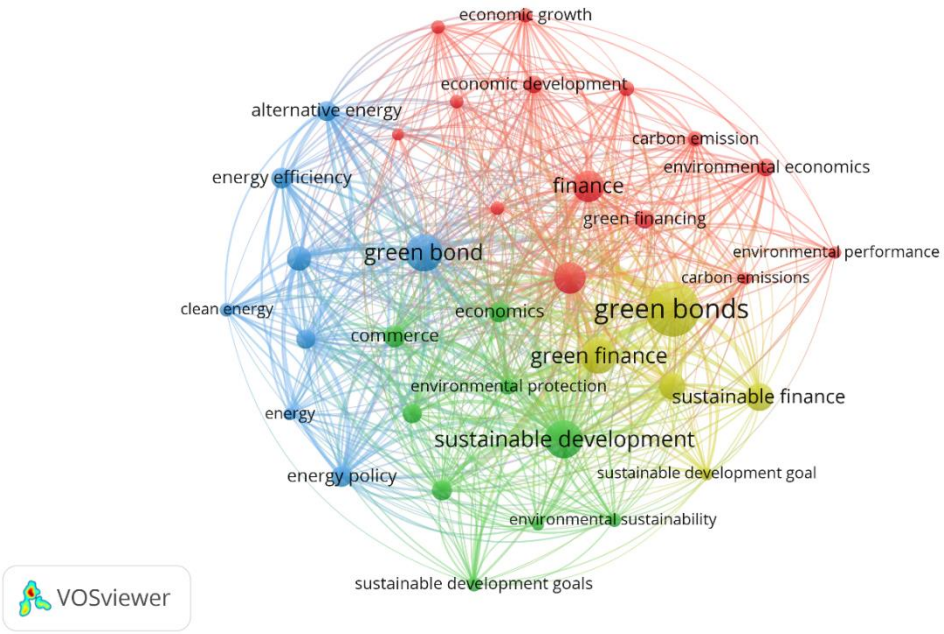

Figure 1. Network Visualization
Source: Data Analysis Result, 2025

Figure 1 presents the network visualization of keyword co-occurrences within the Scopus-indexed literature on green bonds and green financing. The map reveals a highly interconnected and multidimensional research structure, showing that studies on green finance integrate themes from environmental science, economics, energy systems, and sustainability policy. The yellow cluster centered on "green bonds," "green finance," and "sustainable finance" forms the conceptual core of the network, highlighting strong scholarly attention toward the role of green financial instruments in promoting sustainable development and environmental protection. The green cluster, which includes keywords such as "sustainable development," "environmental sustainability," and "sustainable development goals," illustrates the policy and governance dimension of the field and reflects its alignment with global development frameworks. Meanwhile, the blue cluster emphasizes the energy transition through themes like "energy efficiency," "clean energy," and "alternative energy,"

underscoring the role of green financing in supporting renewable energy deployment.

The red cluster represents the economic and financial analytical dimension, dominated by terms such as "finance," "economic growth," "economic development," and "carbon emissions," suggesting that a significant portion of the literature examines how green financing interacts with financial markets, economic structures, and climate-related economic modeling. The tight interconnections among all clusters demonstrate a high degree of interdisciplinarity, positioning green bonds as a bridge between finance, policy, and environmental science. Overall, the visualization signals that the field has evolved beyond isolated thematic explorations toward integrated approaches that combine environmental indicators, economic performance, and sustainability objectives. This rich network structure highlights that green bonds are now examined not only as financial innovations but also as strategic instruments for advancing global decarbonization and long-term sustainable development.

3.2 Thematic Evolution (Overlay Visualization)

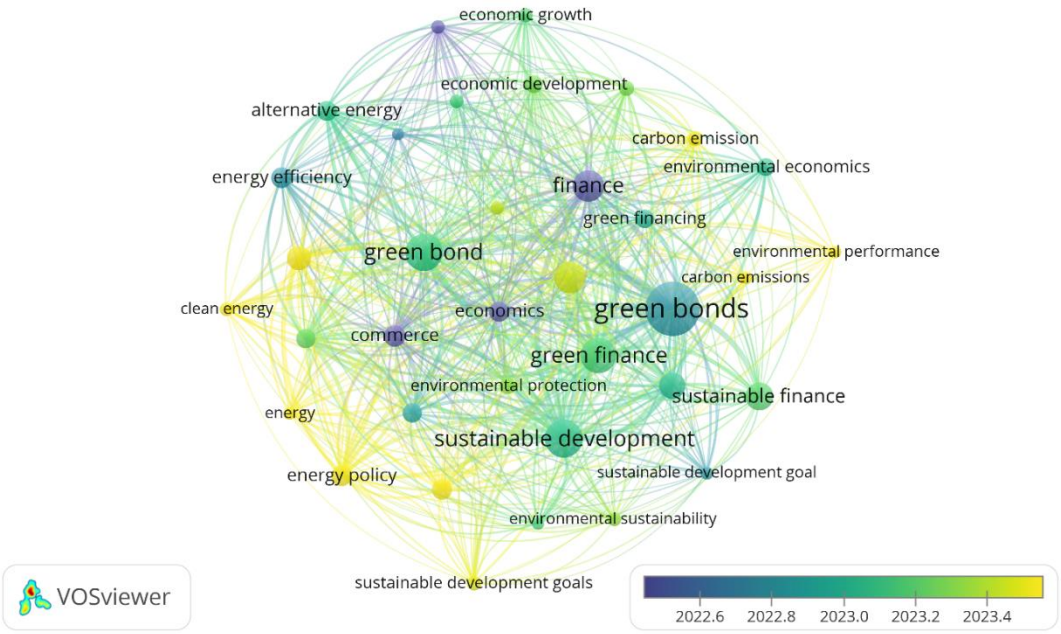

Figure 2. Overlay Visualization

Source: Data Analysis, 2025

Figure 2 presents the overlay visualization illustrating the temporal evolution of research themes in green finance. Earlier studies, represented by blue–green nodes, focused primarily on economic development, environmental performance, and finance, reflecting a conceptual phase in which scholars explored how environmental objectives could be aligned with financial market mechanisms. In contrast, more recent themes, shown in yellow nodes, highlight growing attention to energy efficiency, renewable energy, carbon markets, sustainable finance, and SDG-related issues, indicating a shift toward more applied and systems-oriented research. Overall, the temporal pattern demonstrates the field's progression from foundational frameworks to empirical testing, spillover modeling, and the evaluation of real-world impacts associated with green financing instruments.

3.3 Research Density and Hotspots (Density Visualization)

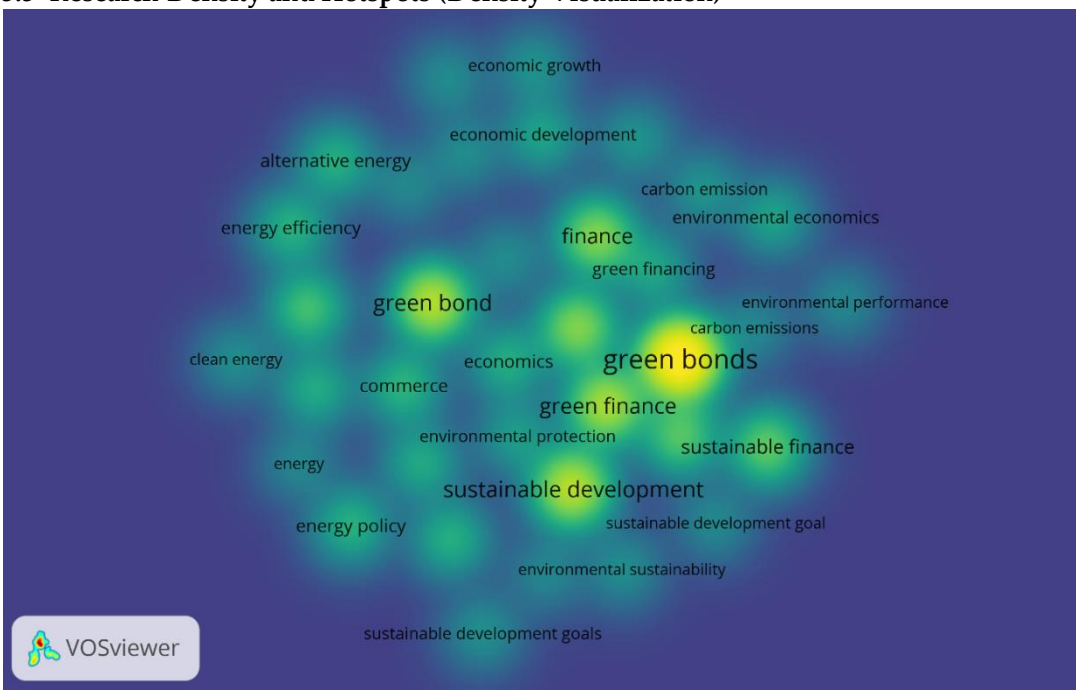

Figure 3. Density Visualization

Source: Data Analysis, 2025

Figure 3 illustrates the density visualization, showing that the highest concentration of research activity is centered on themes such as green bonds, green finance, sustainable development, energy efficiency, and carbon emissions, highlighting strong global academic alignment with urgent environmental challenges. Emerging yet rapidly expanding topics—including clean energy, alternative energy, and environmental protection—suggest new avenues for scholarly exploration and signal the broadening scope of the field. Overall, the combination of finance- and energy-related hotspots underscores the strategic role of green bonds as a key financial instrument supporting low-carbon transitions and sustainable economic transformation.

3.4 Author Collaboration Network

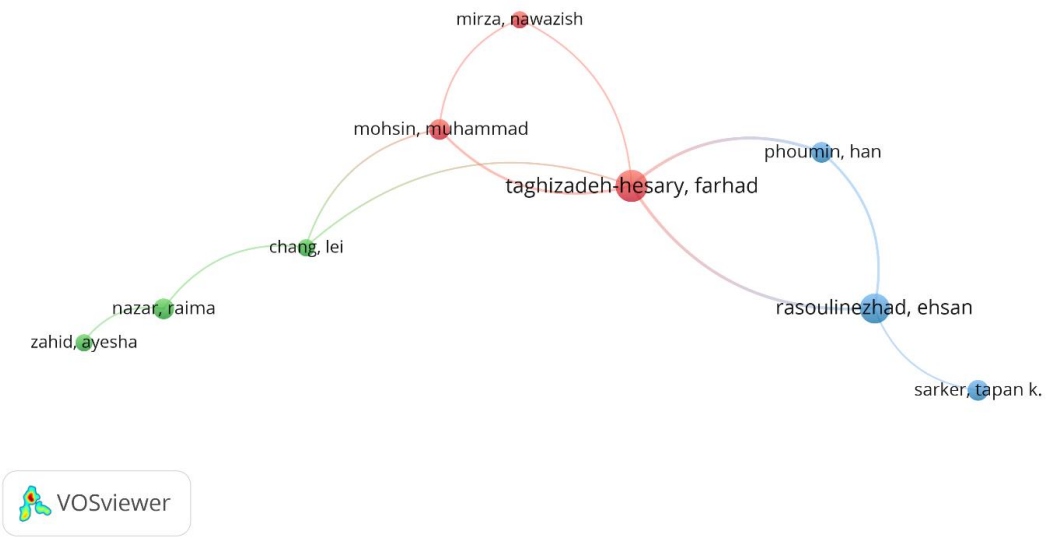

Figure 4. Author Collaboration Visualization
Source: Data Analysis Result, 2025

The author network reveals a concentrated yet gradually expanding collaborative structure, with Taghizadeh-Hesary, Farhad positioned as a central figure who bridges multiple clusters of researchers, including Rasoulinezhad, Ehsan; Mohsin, Muhammad; Chang, Lei; and Sarker, Tapan K., reflecting his strong intellectual influence and cross-country engagement in energy policy and green financing. Other clusters, such as those formed by Nazar, Raima and Zahid, Ayesha, represent independent research groups focusing on green finance and sustainability economics. However, the limited number of cross-cluster linkages indicates that the field remains somewhat fragmented, suggesting considerable potential for enhanced international collaboration to strengthen knowledge integration and broaden the global research impact.

3.5 Affiliation Collaboration Network

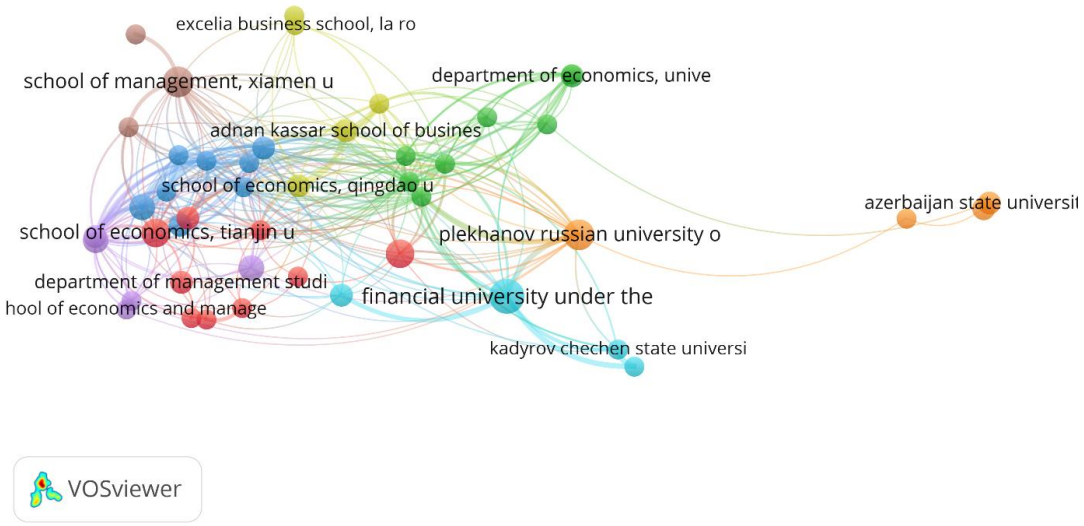

Figure 5. Affiliation Collaboration Visualization
Source: Data Analysis, 2025

The institutional collaboration network indicates that universities in China, Russia, and Europe dominate research in green finance, with key affiliations such as the School of Management at Xiamen University, the School of Economics at Tianjin University, Qingdao University, Plekhanov Russian University, the Financial University under the Government of the Russian Federation, and Exelia Business School in France serving as central hubs that connect various regional research clusters. The dense interlinkages among Chinese institutions highlight China's leading role both in academic contributions and in the practical issuance of green bonds, while the involvement of prominent European institutions reflects strong scholarly engagement aligned with the European Union's green taxonomy and regulatory initiatives. Overall, these institutional networks underscore a geographically diverse yet interconnected research landscape that shapes the evolution of green bond and green financing studies.

3.6 Country Collaboration Network

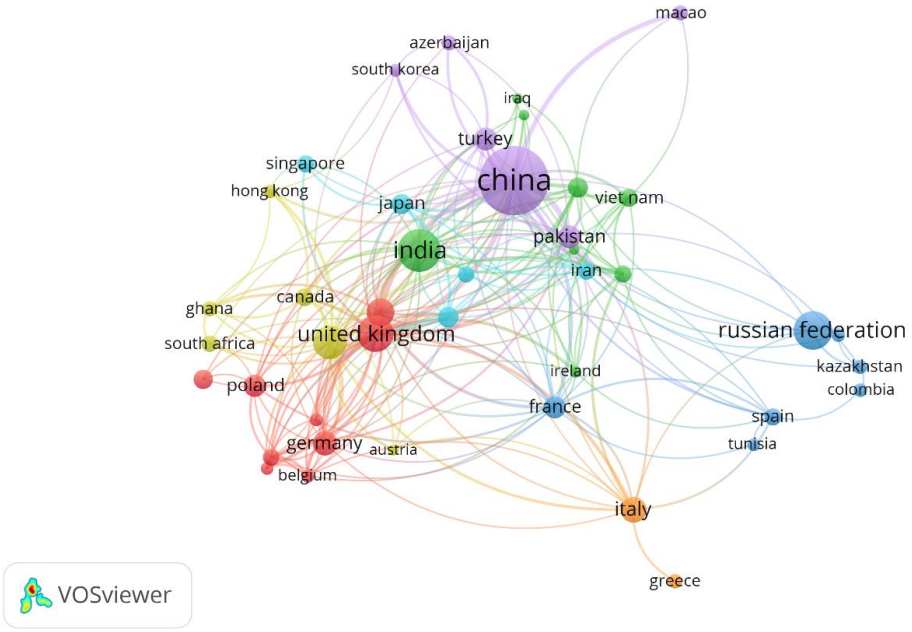

Figure 6. Country Collaboration Visualization

Source: Data Analysis Result, 2025

The country collaboration map positions China, India, the United Kingdom, Italy, and Russia as the most connected countries, indicated by large node sizes. China's dominant position aligns with its status as both the largest issuer and one of the most prolific researchers in green finance. India, the UK, Germany, and France also show extensive connections, highlighting robust participation in global sustainability finance discourse. Countries such as Vietnam, Pakistan, Iran, and South Korea form emerging collaborative clusters. Meanwhile, Azerbaijan, Colombia, Tunisia, and Kazakhstan appear as smaller nodes with fewer links, representing emerging contributors. Overall, the map depicts a highly globalized field, though with stronger collaboration in Europe and Asia

3.7 Citation Performance

Table 1. Top Cited Research

Citations	Authors & Year	Title
412	Gianfrate, G., Peri, M. (2019)	The green advantage: Exploring the convenience of issuing green bonds
307	Bhutta, U.S., Tariq, A., Farrukh, M., Raza, A., Iqbal, M.K. (2022)	Green bonds for sustainable development: Review of literature on development and impact of green bonds
284	Bachelet, M.J., Becchetti, L., Manfredonia, S. (2019)	The green bonds premium puzzle: The role of issuer characteristics and third-party verification
275	Zhang, Y.F., Umair, M. (2023)	Examining the interconnectedness of green finance: an analysis of dynamic spillover effects among green bonds, renewable energy, and carbon markets
274	Wang, J., Chen, X., Li, X., Yu, J., Zhong, R. (2020)	The market reaction to green bond issuance: Evidence from China
271	Sinha, A., Mishra, S., Sharif, A., Yarovaya, L. (2021)	Does green financing help to improve environmental & social responsibility? Designing SDG framework through advanced quantile modelling

233	Zhao, L., Chau, K.Y., Tran, T.K., ... Xuyen, N.T.M., Phan, T.T.H. (2022)	Enhancing green economic recovery through green bonds financing and energy efficiency investments
233	Liu, H., Yao, P., Latif, S., Aslam, S., Iqbal, N. (2022)	Impact of Green financing, FinTech, and financial inclusion on energy efficiency
221	MacAskill, S., Roca, E., Liu, B., Stewart, R.A., Sahin, O. (2021)	Is there a green premium in the green bond market? Systematic literature review revealing premium determinants

Source: Scopus, 2025

Table 1 highlights the most influential research published between 2019 and 2023, forming the conceptual and empirical backbone of contemporary green finance scholarship. The most cited paper, Gianfrate & Peri (2019), introduced the influential concept of the "green advantage," demonstrating that green bonds can offer cost benefits compared to conventional bonds and sparking debate on the existence of a green premium. Bhutta et al. (2022) provide a comprehensive review of the developmental and environmental impacts of green bonds, becoming a widely referenced conceptual anchor in the field. Several high-impact studies focus on pricing mechanisms and transparency, such as Bachelet et al. (2019), who examine the green bond premium puzzle and the role of external verification. More complex empirical works, including Zhang & Umair (2023) and Wang et al. (2020), analyze spillover effects among green financial assets and market reactions to bond issuance, expanding understanding of financial dynamics in sustainable investment. Other influential studies emphasize the social and environmental implications of green finance, notably Sinha et al. (2021) on SDG-oriented modeling and Zhao et al. (2022) and Liu et al. (2022), who explore green recovery, FinTech integration, and energy efficiency. Together, these works trace an evolution from early pricing-focused discussions to broader examinations of renewable energy utilization and environmental performance, exemplified by Ye & Rasoulinezhad (2023).

Synthesizing insights from bibliometric mapping and citation patterns, the findings reveal a rapidly expanding field characterized by strong interdisciplinary convergence across finance, energy, and sustainability studies. Leading research hubs include China, India, the United Kingdom, Germany, and Italy, reflecting both academic activity and real-world commitments to green finance implementation. Dominant empirical contexts center on energy transition, carbon emissions, and the environmental impact of financial instruments, while analytical themes focus on green premiums, environmental performance, and spillover effects. Although author collaborations remain relatively clustered, they highlight opportunities for more integrated and globally connected research networks. Overall, the combined evidence underscores that green bonds have evolved beyond mere financial instruments, becoming strategic tools that support global decarbonization, strengthen environmental responsibility, and accelerate sustainable development agendas.

4. CONCLUSION

This study provides a comprehensive bibliometric overview of the rapidly growing field of green bonds and green financing. The visualizations and citation patterns demonstrate a significant rise in research activity in recent years, highlighting the increasing relevance of sustainable finance within global economic and environmental agendas. Keyword network analysis reveals that scholarly attention consistently converges on themes such as green bonds, green finance, sustainable development, and energy-related topics, illustrating strong interdisciplinary integration across finance, environmental science, and public policy. Collaboration maps further show that China, India, the United Kingdom, Italy, and Russia function as major research hubs supported by influential institutions and expanding international partnerships, while the author network identifies key contributors—such as

Taghizadeh-Hesary, Rasoulinezhad, Mohsin, and Chang—who play central roles in shaping the academic landscape of sustainability finance.

Insights from the most cited publications reinforce the conclusion that green bonds influence financial markets while simultaneously serving as critical instruments for promoting renewable energy adoption, carbon reduction, and progress toward the Sustainable Development Goals. The thematic evolution observed across the literature—from conceptual discussions on green premiums to advanced modeling of spillover effects, energy transitions, and post-pandemic green recovery—indicates a clear shift toward more sophisticated, data-driven, and policy-relevant research. Overall, the findings underscore the strategic role of green financing in supporting global decarbonization efforts and provide a strong foundation for advancing interdisciplinary collaboration, enriching academic discourse, and informing evidence-based policymaking within the green finance ecosystem.

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