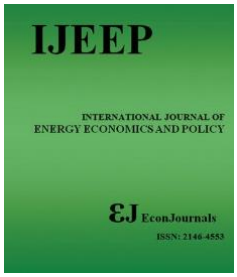

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Bibliometric Insights into Green Finance and Economic Development: Global Trends and Collaborations

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ABSTRACT

Green finance has emerged as a prominent developmental trend in the financial sector, owing to its growing worldwide significance. It has become common practice to address both concerns at once by combining environmental conservation measures with economic growth. But whether green finance can effectively tackle the global economic problems of today is still up for debate. The goal of this study was to identify understudied regions of the world by examining publication patterns in the literature on green finance and economic growth. The study attempted to identify trends in green finance and economic development research publications across nations, continents, contributing authors, and journals. 289 publications that were taken from the Scopus database were used in this bibliometric analysis. The study used a bibliometric technique using R Studio software. The study identifies the most prolific and noteworthy authors, articles, and related publications. Specifically, co-citations and collaboration analysis allowed for the mapping of the most current and oldest research fronts. With a disparate quantitative production of scientific literature among nations and organizations, this field of study is still relatively young. As a means of promoting research in the field of green finance and economic development, this study painted a picture of an emergent, multidisciplinary sector that may be of interest to all stakeholders dealing with similar problems. The findings offer solid recommendations for more research in this area.

Keywords: Green Finance, Environmental Finance, Economic Development, Economic Growth, Bibliometrics
JEL Classifications: O1, Q01, Q5, Q56

1. INTRODUCTION

As the effects of climate change worsen, there is a renewed focus on sustainable development, climate change, and green economic development (Lazaro et al., 2023). Economic development is critical for improving people's standard of living (Nenavath, 2023). The expansion of economies drives industrialization, which accelerates resource extraction, degrades agricultural productivity, and hastens the rate of degradation of natural resources (Umar et al., 2020). India's tremendous economic growth and developmental advances during the past few years have been revolutionary, and the country is on track to become a USD 5 trillion economy by 2025 (Sawhney, 2021). In the current era of fast-paced economic development, economies often tend to overlook the environment, which provides sustenance to the human race. Climatic variations and the damage they cause to the environment are also the most pressing issues (Abbass et al., 2022). The dearth of attention to controlling pollutant emissions has resulted in a substantial increase in global temperature, environmental pollution, and a significant deterioration of the ecological conditions (Yang et al., 2023). Because of this, the Earth is presently around 1.1°C warmer than it was in the nineteenth century and the hottest decade on record occurred between 2011 and 2020 (Kendon et al., 2021). Thousands of experts and governmental reviewers concurred in several UN assessments that keeping the rise in global temperature to 1.5°C

would help avert the worst effects of climate change and preserve a habitable environment (Balaram, 2023). Despite its swift economic expansion, India has the challenge of increasing resource efficiency and reducing environmental pollution in order to achieve sustainable and green economic growth (Nenavath, 2023). To deal with such situations, green finance is a groundbreaking endeavor in the realm of finance that relates economic growth with positive environmental impacts (Mohanty et al., 2023). This means green financing is viewed as the convergence point of economic expansion and environmental conservation (Muchiri et al., 2022).

Sustainability is an essential goal for India, which is to become a Viksit Bharat by 2047 (Mahida, 2024). While India wants to become carbon neutral by 2070 (Midha and Tomar, 2024), significant progress must be made in that direction. The Indian government has also updated its Nationally Determined Contributions in 2022. As per this updation, the revised objective for reducing the emissions intensity of its gross domestic product (GDP) has been increased to 45% by 2030 from 2005 levels (Chaturvedi et al., 2021).

In India, through encouraging responsibility and accountability, green finance can make a substantial contribution to a secure and thriving economy. This entails shifting financial resources from environmentally harmful investment avenues to commercial ventures that reconcile social, environmental, and economic goals in order to raise living standards and lessen global issues like inequality, climate change, and biodiversity loss (Alsmadi and Alzoubi, 2022). Several studies have shown a significantly positive association between green finance and economic development (Gao et al., 2022; Han and Gao, 2024; Liu and Pan, 2024; Ouyang et al., 2023; Zhang and Zhao, 2024) These studies posit that by enhancing the degree of innovation (Yan and Lyu, 2023), coordination (Wang et al., 2022), greenery (Cai et al., 2023), openness (Hao, 2024), and sharing (Liu and Li, 2024); green finance contributes significantly to the economic development of the nation. Thus, in addition to supporting environmental protection and green growth, green finance promotes economic structural adjustment and industrial upgrading by reducing environmental pollution and ecological damage.

The objective of this current study is to analyze the available literature in the field of green finance and economic development. First, it presents the most recent state of research and its evolution patterns according to the volume of literature, journal distribution, geographical distribution, the prolific authors, the institutions, and the co-citation analysis. Second, the study also examined the issue of green financing and economic development from a longitudinal perspective. Lastly, to this end, the research aims to examine how differences in ideas across the globe collaborated to produce scholarly articles on green finance and economic development.

Intending to contribute and draw a big and holistic portrayal of relevant academic research work in the realm of green finance and economic development, this paper has used the bibliometric method of research. As a quantitative approach, Bibliometric analysis is a popular and rigorous method for exploring and analyzing large volumes of scientific data with the help of statistical tools and techniques (Donthu et al., 2021). The bibliometric analysis is considered an effective quantitative methodology that provides a thorough and in-depth understanding of developing research fields (Wang et al., 2020). By exposing the features including topics, authors, publications, categories, keywords, references, citations, and intellectual structure, a methodical analysis of previous studies, the current study could assist researchers in promptly identifying the current research trend, hotspots, and upcoming advancements in a specific discipline (Nobanee et al., 2021). The contribution of this study is twofold. First, this study contributes by tracking the number of issues in the area of green finance and economic development over the past couple of years while highlighting their growth trajectories and dominant positions in the literature. Second, it identifies the pertinent keywords from the existing pool of literature in an effort to encourage future researchers to undertake research on burning themes in the relevant discipline.

Continuing with this paper, we have the following sections: The second section presents the data sources and the method of research, the third section describes the research network, and Section 4 analyzes it. This section describes the evolutionary stage of the theme, and section 5 describes the summary of the main conclusions and recommendations provided, based on the bibliometric investigation, for future work.

2. METHODOLOGY

The main objective of this study was to assess existing research on green finance and economic development and to create a network of keywords related to this main theme. To the best of researchers' knowledge, several previous studies have performed systematic literature reviews and bibliometric analyses on "Green Finance" as the main theme (Alsmadi et al., 2023; Bhatnagar and Sharma, 2022; Rusydiana, 2024; Sharifi et al., 2021; Yu et al., 2021), but the novelty of this study lies in the fact that the current study is the first one where the central theme of applying the bibliometric approach is "Green Finance and Economic Development." Compared to the conventional systematic literature review, the creation of a bibliometric technique is unique (De Bakker et al., 2005). It is the most effective approach for carrying out research that draws information from science and libraries (Kumar et al., 2020). All documents in the fields of business and economics, social sciences, environmental sciences, and other multidisciplinary fields that deal with green finance and economic development are analyzed using bibliometric science. It makes it possible to create network analyses, which give an accurate view of the connections between different scientific research, nations, authors, and keywords. It also establishes the co-occurrence of keywords and gives a summary of how the different themes have changed over time (Sarkodie and Owusu, 2020).

We created a search strategy specifically for this review in order to find pertinent literature on the particular subject. The Scopus database was the primary source for this search technique. The justification for utilizing this database is that prior research has deemed it to be the most comprehensive and highly recommended source (Harzing and Alakangas, 2016). Scholars define green finance differently, but the breadth and substance remain identical

(Lindenberg, 2014). Due to the large number of terms used in the field, we have limited the list to green finance, green investment, green credit, green loan, environmental finance, Climate finance, and carbon finance. This has been done by considering the information presented in the papers and their applicability. The term "Sustainable Finance" has not been used as a keyword in searching the relevant literature in the field of green finance and economic development as the betterment of the economy, society, and environment at large is the main objective of a sustainable financial system whereas green financial mechanism is focused on specifically environmental dimension (Azad et al., 2022). Further, for the term economic development, economic growth has also been used as a keyword because both have been used interchangeably in various literature.

Soon after figuring out the most relevant keywords in the realm of green finance and economic development that were beneficial for the review, literature was extracted using the following keywords All= (("Green Finance" OR "Green Investment" OR "Green Credit" OR "Green Loan" OR "Environmental Finance" OR "Climate Finance" OR "Carbon Finance") AND ("Economic Development" OR "Economic Growth")). The researchers devised standards for selecting and rejecting publications for examination in the planned research. In doing so, studies written in English are included, while research written in other languages is omitted. Further, only "Articles" that come from the "Economics, Econometrics and Finance" and "Business, Management and Accounting" fields were selected for further analysis. The PRISMA declaration serves as the foundation for the selection criteria (Meyer, 1997). Overall, 1041 papers were found using Scopus; 289 research papers were accepted for the study after the pertinent studies were screened to ensure they were within the purview of the review. The methodology used to choose the documents that were taken from the database is depicted in Figure 1 below.

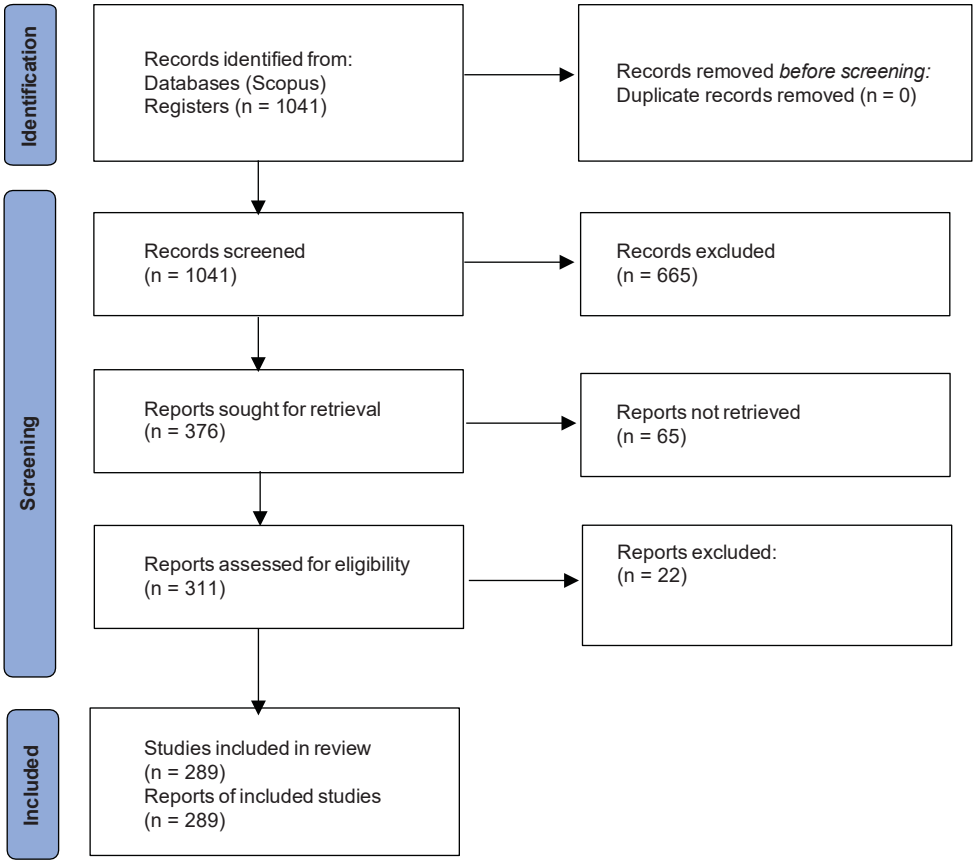
The scrutinized research papers utilized in this investigation were procured from Scopus using an advanced search conducted using the selected keywords. The papers that were downloaded from Scopus are the inputs. The data analysis was performed using the free open-source software named "R Studio." The R programming language is utilized to execute the open-source Bibliometrics and Biblioshiny packages. The Bibliometrics package assists users in completing the entire process of analyzing scientific literature and processing data, while Biblioshiny, an internet-based data analysis platform, is based on the fundamental Bibliometricrix algorithm (Aria and Cuccurullo, 2017), which provides users with the ability to conduct pertinent bibliometrics and data visualizations.

3. RESULTS AND INTERPRETATIONS

3.1. Descriptive Analysis

The review for the present study was shaped by obtaining resources from the database chosen for this study. After satisfying all inclusion-exclusion criteria, 289 papers were selected for the final discussion. Therefore, the following section discusses the descriptive analysis of the study.

Figure 1: Study selection process flowchart



Source: Authors' compilation

In order to compile and examine the data, we first carried out a descriptive analysis of the database that was utilized. The primary database statistics are displayed in Table 1. The analysis period spans from 2009 to 2024, with an annual growth rate of 32.49%. The average citation for the 289 items in the database is 22.34. A total of 717 authors contributed to the current pool of knowledge, with an average of 2.48 authors per article.

3.2. General Statistic

One of the key metrics for gauging the advancement of the research in the field of "Green Finance and Economic Development" is the shift in the output of publications. Concerning the yearly fluctuations in the amount of literature produced in this discipline, the historical trajectory of its ascent and descent can be understood. Figure 2 depicts the chronological progression of literature production in the realm of green finance and economic development.

From the graph, it can be observed that the research on green finance and economic development began in 2009 and entered the discipline development period in 2018 after a slow growth of 9 years. After 2021, literature in the relevant field has been produced at a very fast pace. While there seems to be a downward trend for 2024, this is mostly because the year is still in its infancy. Considering the amount of literature available, it is significant to highlight that 68 publications have already been registered in the first 4 months of 2024, compared to a total of 118 publications generated in the field of "green finance and economic development" in 2023.

The rise in the number of papers might be attributed to the end of the subprime crisis in 2008. After that, the world economy started to recover, and academics started thinking about ways to leverage green financial instruments to advance sustainable green growth of the economies. The Paris Agreement and Sustainable Development Goals agreed in 2015 represented a watershed moment, resulting in an increase in green financing for sustainable economic development.

3.3. Authors and Institution Distribution

Green finance and its impact on economic development is a fascinating subject with a wide range of real-world applications and theoretical possibilities. The term "core group" designates a collection of authors/institutions with a higher impact and volume of publications. (Price, 1963) states that only a certain proportion of writers/institutions that have written on a particular topic are eligible to become core authors.

Theoretical calculations indicate that the key writers of green finance are academics who have published two or more papers, and the core institutions are those with volumes of five or more. Tables 2 and 3 display the most relevant authors and most relevant affiliations working in the realm of "green finance and economic development." With 112 publications or 29.17% of the core authors, China tops the list of most relevant authors in the current field. Similarly, scholarly publications from Chinese Universities are the most prolific, as the top 10 affiliations publishing green finance and economic development literature with a total number

Table 1: Descriptive analysis

Description	Results
Article	289
Timespan	2009:2024
Annual growth rate %	32.49
Average citations per doc	22.34
Authors	717
Authors of single-authored docs	33
Authors per article	2.48
Co-authors per doc	3.14
Keywords plus (ID)	1070
Author's keywords (DE)	766

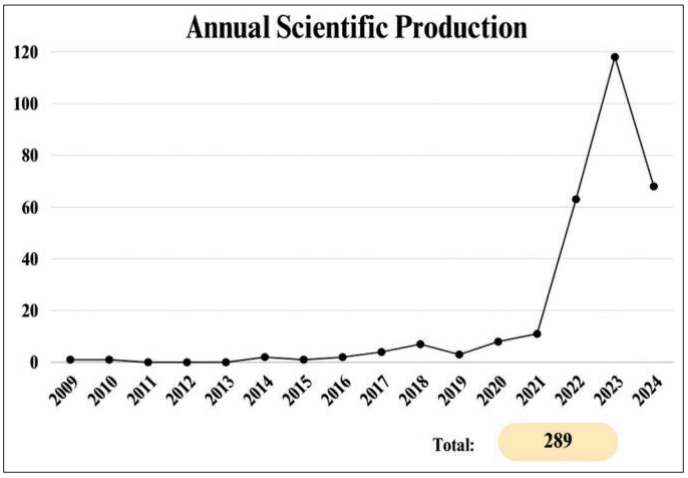
Table 2: Th top 10 contributing auth ors, number of articles, an articles fractionalized

Authors	No. of published articles	Articles fractionalized
WANG Y	12	3.32
WANG X	7	2.75
ZHAO X	7	2.07
ZHANG D	6	3.92
CHEN H	5	1.6
LEE C-C	5	1.67
LIU Z	5	1.32
WANG Q	5	1.73
ZHANG Y	5	2.12
CHEN Z	4	1.03

Table 3: The top 10 contributing organiza tions

Affiliation	Country	Articles
Nanjing normal university	China	15
University of International Business and Economics	China	15
Nanjing University of Aeronautics and Astronautics	China	13
Tianjin University of Commerce	China	12
Jilin University	China	11
Qingdao University	China	11
Xinjiang University	China	10
Zhongnan University of Economics and Law	China	10
Fuzhou University of International Studies and Trade	China	9
Nanchang University	China	9

Figure 2: Number of published articles per year



Source: Authors' compilation

of 115 articles, reflecting that China's academic institutions are also the most relevant ones.

3.4. Journal Distribution

The distribution of core journals in a field can be ascertained via the periodic study of the subject area. The journal map of green finance and economic development is displayed in Table 4. A preliminary statistic shows that 289 articles were published in 86 different journals.

With 75 or 25.95% of papers overall, Resources Policy is the journal that has published the most articles on green finance and economic development, with the highest H index of 23 and a total number of citations of 1697. But, at the same time, despite having published only 6.92% or 20 articles, the Journal of Cleaner Production is a high-quality publication with an H index of 15 and a total number of citations of 852, because of its high degree of centrality. By observing Table 4, it can be inferred that the resources, production, energy, economy, ecology, sustainable development, finance, technology, and agriculture are the essential periodicals to cover the underlying topics. In other words, individuals from all backgrounds are now embracing green financing.

Table 4: The top 10 publishing journals contributing to the area of green finance and economic development

Sources	No. of articles	Percentage of articles
Resources policy	75	25.95
Journal of cleaner production	20	6.92
Energy economics	16	5.54
Economic research-ekonomska istrazivanja	14	4.84
Economic analysis and policy	13	4.50
Economic change and restructuring	13	4.50
Environment, development and sustainability	12	4.15
International journal of energy economics and policy	11	3.81
Ecological economics	6	2.08
Frontiers in energy research	5	1.73

Source: Authors' compilation

3.5. Most Cited Documents

This section will provide a brief picture of those articles that are highly cited by researchers in the research field. Tables 5 and 6 show the top 10 most globally and locally cited articles respectively.

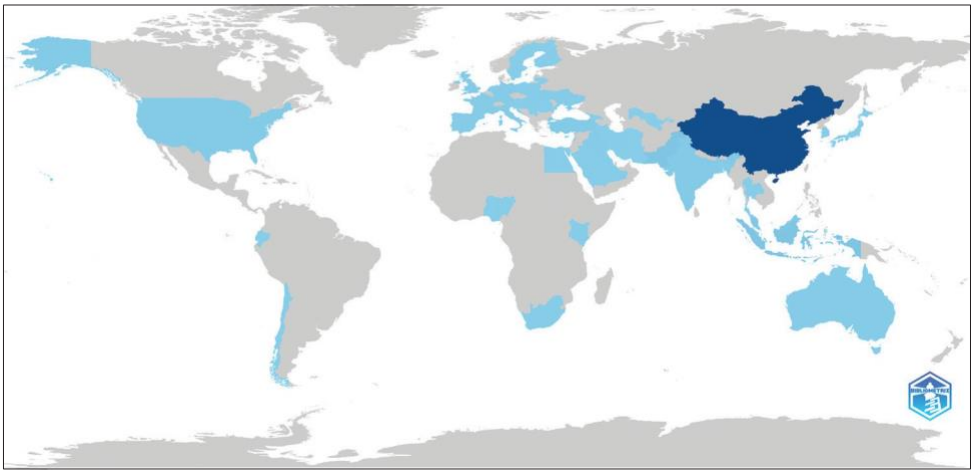
3.5. Country Distribution

The publications published by the nation are displayed in Figure 3. The intensity of the color and the quantity of articles are proportional to each other. The blue hue denotes the number of articles produced in each nation. The increased output corresponds with a darker color. Overall, the regional distribution suggests that green finance and economic development studies and practices have garnered global interest.

Further, Table 7 of the study displays the frequency of particular nations producing scientific research throughout time. The study focused on the top ten leading nations. As a consequence, it was discovered that China was the top nation providing scientific research on green finance and economic development. A total of 76 countries have participated in economic development via green financing activities. The top 10 countries include 5 Asian nations (India, Pakistan, China, Indonesia, and Malaysia), 4 European nations (United Kingdom, Germany, Ukraine, and Turkey), and 1 North American nation (the United States of America).

Compared to other nations, India's rapid economic growth and its rich biodiversity and natural resources have necessitated the integration of green finance in economic activities., making green funding critical. As an industrial hub, China emits a large amount of carbon dioxide, hence, investing in green projects is crucial to mitigating the ecological impact of anthropogenic activity. In a similar vein, the Equator Principles, which mandate that financial firms take social and environmental factors into account before making investments, were embraced by the US, Germany, and the UK and they are the ones who pioneered environmental laws. For them, making investments in sustainable economic practices is imperative. Pakistan is also suffering from significant environmental harm, making it critical to explore green finance. Furthermore, because of their sophisticated financial structures, Malaysia, Turkey, and Indonesia all heeded part in green economic

Figure 3: Countries' scientific production



Source: Authors' compilation

Table 5: The Top 10-most cited articles (Global)

Author	Article	Total Global Citations	TC Per Year
(Irfan *et al*., 2022)	Influence mechanism between green finance and green innovation: Exploring regional policy intervention effects in China	311	103.67
(Zhou *et al*., 2022)	The impact of fintech innovation on green growth in China: Mediating effect of green finance	243	81
(Jiakui *et al*., 2023)	Green technological innovation, green finance, and financial development and their role in green total factor productivity: Empirical insights from China	223	111.5
(Lv *et al*., 2021)	Regional gap and the trend of green finance development in China	214	53.5
(X. Wang & Wang, 2021)	Research on the impact of green finance on the upgrading of China's regional industrial structure from the perspective of sustainable development	211	52.75
(Yang *et al*., 2021)	Nexus between green finance, fintech, and high-quality economic development: Empirical evidence from China	208	52
(Soundarrajan & ViveK, 2016)	Green finance for sustainable green economic growth in India	174	19.33
(D. Zhang *et al*., 2022)	Does green finance counteract the climate change mitigation: Asymmetric effect of renewable energy investment and R&D	131	43.67
(Sadiq *et al*., 2022)	Does green finance matter for sustainable entrepreneurship and environmental corporate social responsibility during COVID-19?	119	39.67
(Yin & Xu, 2022)	An empirical analysis of the coupling and coordinative development of China's green finance and economic growth	118	39.33

Table 6: The Top 10-most cited articles (Local)

Document	Articles	Local Citations
(Soundarrajan & Vivek, 2016)	Green finance for sustainable green economic growth in India	16
(Afzal *et al*., 2022)	Green finance and sustainable development in Europe	12
(Bai *et al*., 2022)	Research on the impact of green finance on carbon emissions: evidence from China	9
(B. Zhang & Wang, 2021)	The Effect of Green Finance on Energy Sustainable Development: A Case Study in China	9
(Zhao *et al*., 2023)	How green growth affects carbon emissions in China: the role of green finance	4
(Sadiq *et al*., 2022)	Does green finance matter for sustainable entrepreneurship and environmental corporate social responsibility during COVID-19?	4
(Khoa Dang Duong & Hai Thi Thanh, 2022)	Association between post-covid socio-economic development and energy-growth-environment nexus from developing economy	3
(Su *et al*., 2022)	Can green credit reduce the emissions of pollutants?	3
(Pueyo, 2018)	What constrains renewable energy investment in Sub-Saharan Africa? A comparison of Kenya and Ghana	2
(Yuan & Gallagher, 2018)	Greening Development Lending in the Americas: Trends and Determinants	2

Table 7: The top 10 most productive countries

Region	Articles	Percentage of articles
China	529	0.64
Indonesia	37	0.04
Pakistan	36	0.04
Malaysia	24	0.03
India	18	0.02
UK	18	0.02
Turkey	14	0.02
USA	14	0.02
Germany	13	0.02
Ukraine	12	0.01

Source: Authors' compilation

initiatives. Overall, sustainable economic practices are seen as crucial for curbing environmental damage in these countries.

Figure 4: Word cloud

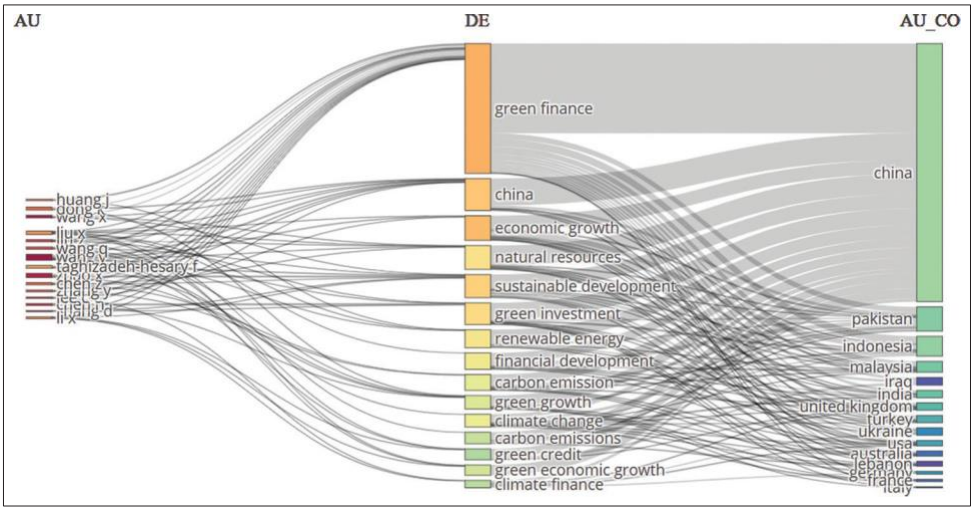
Further, Table 8 also shows that where India, United Kingdom, Indonesia, Pakistan, and Malaysia have produced 48, 53, 81, 88, and 49 documents respectively over the past 5 years, the Republic of China is leading with a total number of 1089 literature in the relevant field during the same period of time.

Table 8: The top 6 most productive countries over the past 5 years

Year	India	China	United Kingdom	Indonesia	Pakistan	Malaysia
2020	3	14	2	1	3	0
2021	5	32	5	1	4	1
2022	9	132	10	9	15	9
2023	13	382	18	33	30	15
2024	18	529	18	37	36	24

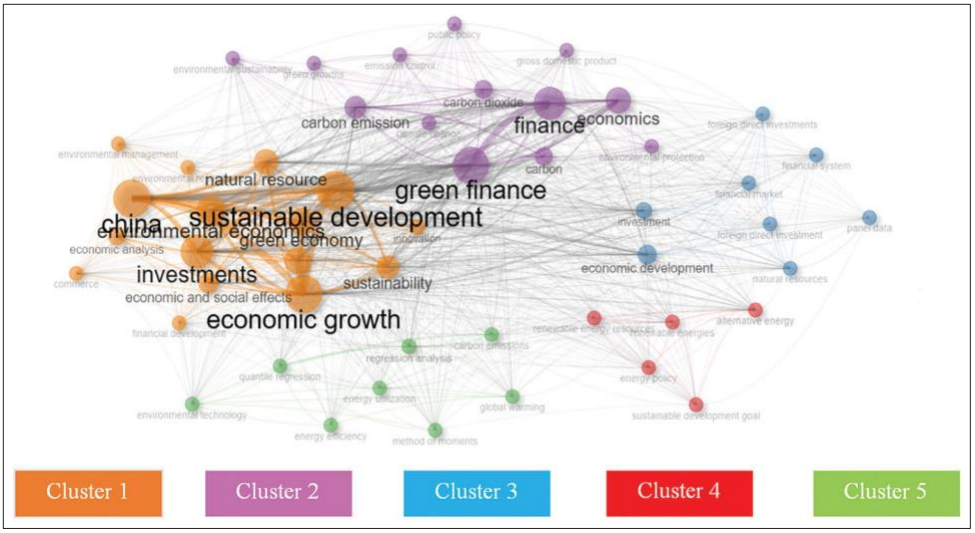
Source: Authors' compilation

Figure 5: Three-field plot



Source: Biblioshiny

Figure 6: Co-occurrence network (keyword plus)



Source: Biblioshiny

3.6. Keyword Analysis

In bibliometric research, keyword analysis is regarded as a basic means of articulating the knowledge structure to illuminate the most thriving words in the research field (Pesta et al., 2018). Creating a keyword co-occurrence matrix is an effective approach to identifying the research composition. This approach uses correlation metrics to identify relationships between words (Desalegn and Tangl, 2022b). The co-occurrence network creates a network map by highlighting the association between keywords. A related area of bibliometric research is detecting hotspots and analyzing trends based on keyword frequency analysis.

Based on the number of associations and the strength degree of their interaction, the top 10 rated keywords for the investigation of the literature on green finance and economic development are displayed in Table 9. Besides this, Figure 4 illustrates the word cloud for specific investigations. The terms that regularly come up in discussions of green finance and economic development are reflected in the word cloud created by using the authors' keywords. According to the keyword analysis, the majority (40%) of the materials analyzed for this study contained the term "green finance."

This term is networked with other keywords, such as economic growth, China, sustainable development, green investment, natural

resources, renewable energy, financial development, climate change, and carbon emission which have the same purpose but are different in their content and scope (Debrah et al., 2022). More precisely, it is clear from the uncovered keywords that China differs from the other terms in significant ways; where the other keywords are related directly or indirectly to the environment, China represents a country. But it also suggests that most research on green finance and economic development comes from China, which may encourage authors to use green finance and economic development and China as keywords in tandem. China therefore often comes up while searching for "green finance." The findings of the study also suggest that the phrase "green finance" is commonly used in China to investigate economic growth, sustainable development, natural resources, renewable energy, climate change, and carbon emissions. The analysis also highlights the practice of using green investments as the proxy for green finance in the scholarly literature. Similarly, where the other keywords specifically focused on environmental aspects, the use of financial development as a keyword in the literature underlines the importance of developing the financial system as a whole because ultimately it is the primary need for providing a solid foundation for the further development of green finance and economic development mechanism in the economy.

3.7. Three-Field Plot Overview

The three-field graphic provided by Biblioshiny of R Studio identifies nations with strong scientific productivity, main authors for green finance and economic development, and associated keywords. Figure 5 of the study displays a single map that illustrates the link between the most cited authors, keywords, and nations. By observing the figure, it can be inferred how strongly the keyword green finance is associated with China. Moreover, the major authors in this field also belong to the country of China. Other prominent keywords used in this area include economic growth, natural resources, sustainable development, green investments, renewable energy, financial development, carbon emission, green growth, climate change, green economic growth, and climate finance. China is a prominent country in terms of producing literature on green finance and economic development, as almost all the keywords are primarily associated with China. Following China, Pakistan, Indonesia, and Malaysia are also performing well in the realm of green finance concerning economic development. The authors also show a strong connection with the term "green finance" as all the top 15 authors in this domain have used this keyword extensively. This finding coincides with the results of sections 3.3, 3.6, and 3.7.

Table 9: Top 10-most frequent authors' keywords

Author keywords (DE)	No. of articles
Green finance	128
Economic growth	29
China	28
Sustainable development	27
Green investment	26
Natural resources	21
Renewable energy	21
Financial development	15
Climate change	14
Carbon emission	13

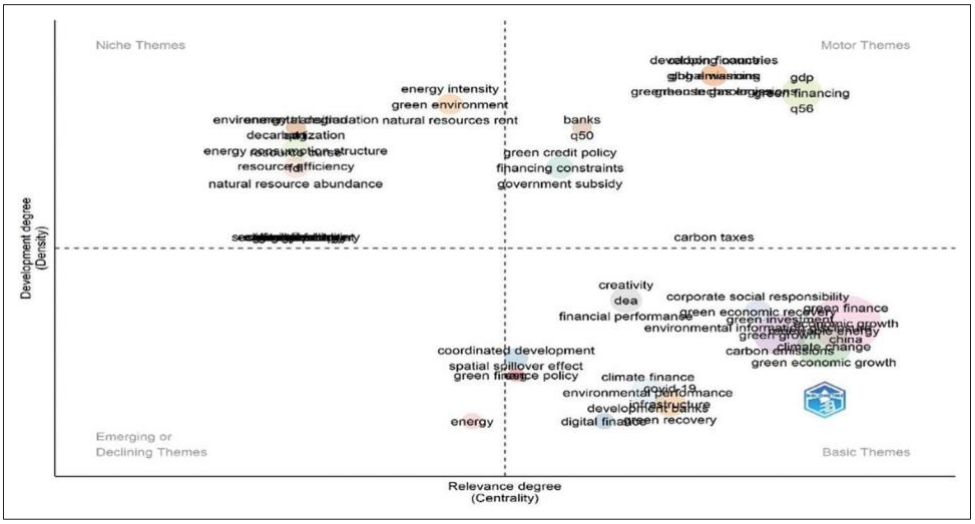
Source: Authors' compilation

3.8. Co-Occurrence Network

Co-occurrence analysis is a bibliometric technique used to investigate the possible association between two bibliographic items that are included in the same study. It is a method of visualizing keywords or words that are commonly used and have an extensive number of connections uncovered in publications on a particular field of interest. The nodes account for keywords, the edges account for links between the keywords, and the thickness of the edges and the closeness of the nodes indicate the frequency with which the keywords co-occurred (Donthu et al., 2021).

As illustrated in Figure 6, the analysis performed using keyword plus yielded five clusters with five or more keywords each. Keyword Plus presents a broader spectrum of the keywords used in existing literature (Ribeiro et al., 2022). Cluster 1 emphasizes the significance of integrating sustainability into economic growth plans by concentrating on sustainable development and the way it interacts with growth. The focus of Cluster 2 is on green finance and how it relates to environmental sustainability. The phrases gross

Figure 7: Thematic map (authors' keywords)



Source: Biblioshiny

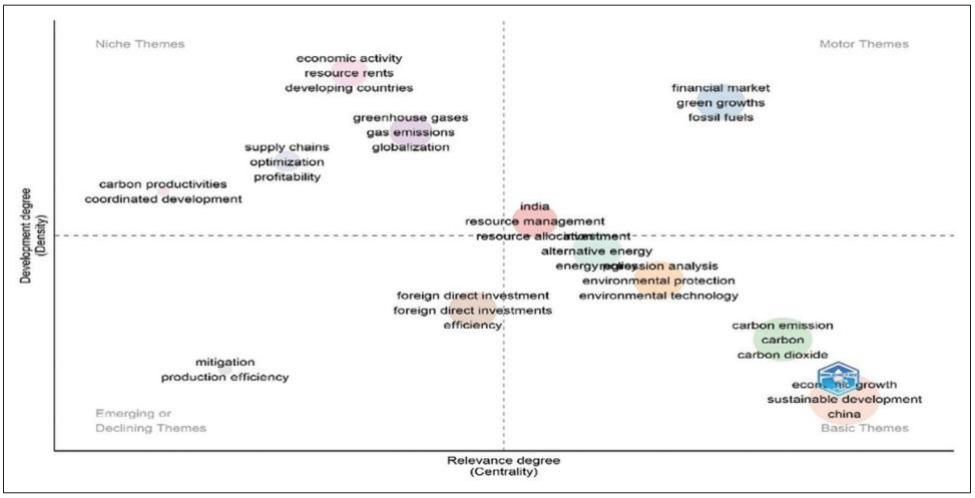
domestic product, green growth, public policy, carbon emissions, and climate change are important ones. These phrases highlight the ways in which green finance may support environmental preservation and economic growth while reducing the effects of climate change. Cluster 3, which focuses on economic growth, highlights how financial institutions and investment strategies may maximize the utilization of natural resources to promote economic progress. Figure 7 also shows the importance of clean energy since the central theme of Cluster 4 is renewable energy sources. This cluster is concentrated on innovations and policy frameworks related to the adoption and integration of renewable energy sources with the broader goal of sustainable development. Similarly, last but not least, Cluster 5 is based on energy efficiency. This cluster delves into the research surrounding the optimization of energy usage to minimize carbon emissions and mitigate the adverse impact of climate change. This cluster also aims to suggest how advancements in technology and energy management practices can enhance energy efficiency and contribute to environmental sustainability.

3.9. Thematic Map

The thematic map is a two-dimensional (2D) representation of the degree of development of the themes based on the external linkages (centrality) and internal strengths (density) of the keywords in the examined texts. The first is density, which is a measure of how well the themes have developed based on internal keyword relationships. The second metric is centrality, which assesses the significance of themes based on external relationships between terms. The map depicts four quadrants: (a) motor themes (high density and high centrality), (b) basic themes (low density and high centrality), (c) niche themes (high density and low centrality), and (d) emerging/declining themes (low density and low centrality) (Bretas and Alon, 2021).

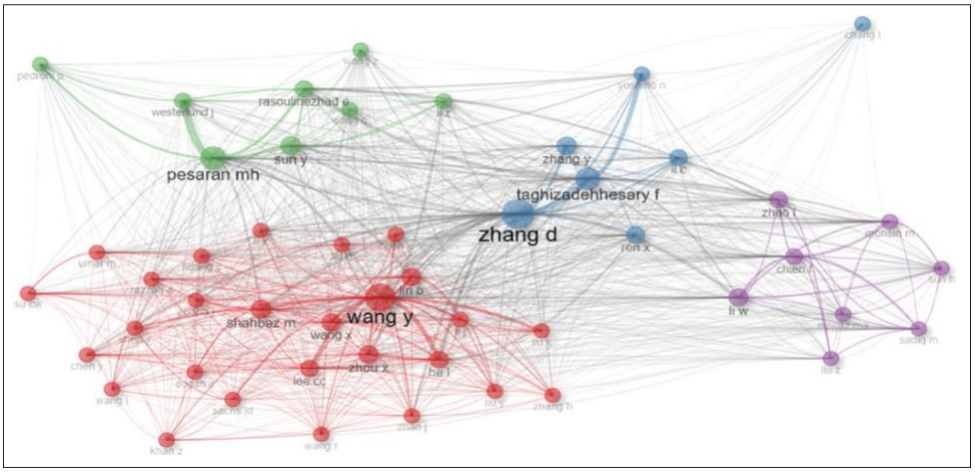
The Motor theme of the thematic map (Figure 7) indicates the role of green finance in facilitating economic development and environmental sustainability, especially in ASEAN countries and developing nations. Additionally, it draws attention to how governments, banks, and green credit policies could ease the financial barriers for environmentally conscious initiatives in emerging ASEAN countries, therefore fostering sustainable economies and cutting greenhouse gas emissions. Unsurprisingly, the basic themes signify a comprehensive exploration of the intersection of economic activities and environmental well-being amid the challenge of COVID-19. In particular, it shows how China's climate change may be mitigated by climate financing

Figure 8: Thematic map (authors' keywords)



Source: Biblioshiny

Figure 9: Authors' co-citation analysis



Source: Biblioshiny

and the digitalization of financial services, resulting in sustainable economic growth. The phrase "corporate social responsibility" emphasizes corporations' environmental stewardship, as it is their responsibility to promote a better environment while extracting resources from the community. Furthermore, within the larger field of green finance and economic growth, the Niche theme of the thematic map represents a specialized area of investigation through an emphasis on resource efficiency and natural resource rent. It focuses on achieving carbon neutrality and decarbonizing economies. The nations may also create a more environmentally friendly atmosphere by changing the composition and intensity of their energy usage. Last but not least, the thematic map's Emerging/Declining themes emphasize the coordinated growth of economies as adjustments in one nation's environmental and economic circumstances may have an impact on another. Therefore, research on the comprehensive growth of economies is desperately needed, and green finance policies should be the main priority in order to boost universal advancement and sustainability worldwide.

Moreover, the thematic map (refer to Figure 8) generated by utilizing the keyword plus indicates that the motor theme centers on comprehending the interplay among green growth, finance, resource allocation, and resource management, particularly within the Indian context and its dependence on fossil fuels. The research centered on the investigation of financial market mechanisms that might support the Indian economy's transition from fossil fuel consumption to renewable energy sources, as suggested by the keywords. Furthermore, the use of the keyword "India" denotes a specific geographic focus, perhaps highlighting the nation's significant contribution to the world's energy consumption as well as its efforts to strike a balance between environmental sustainability and economic development, given that India has set a goal of becoming carbon neutral by 2070.

Table 10: The top 10 authors with high between ness and closeness

Authors	Betweenness	Authors	Closeness
Wang Y	7.931	Wang Y	0.013
Lee Cc	2.819	Lee Cc	0.013
Shahbaz M	3.542	Shahbaz M	0.013
Umar M	2.439	Umar M	0.013
Su Cw	1.801	Su Cw	0.013
Wang X	2.487	Wang X	0.013
Lin B	2.697	Lin B	0.013
Razzaq A	2.257	Razzaq A	0.013
He L	2.172	He L	0.013
Liu H	2.68	Liu H	0.013

Source: Authors' compilation

By observing the basic theme of the thematic map, it can be inferred that in the current scenario, China is the most common country known for researching and investing in green initiatives. Basic themes emphasized how the adoption of environmental technology and alternative energy sources can lead the path of environmental sustainability by reducing the emission of carbon dioxide, along with economic growth. The niche theme highlights the need to study how the amount of carbon produced while performing economic activities can be minimized. This can be done by focusing on coordinated development where the whole world simultaneously focuses on economic, social, and environmental dimensions. Special mention of developing countries as a keyword underlines the necessity of exploring the role of natural resource rent in shaping a safe and clean environment by optimizing the role of supply chains in production and distribution processes. The last theme, the emerging/declining theme in the thematic map, suggests that climate mitigation and production efficiency are now the least focused themes in the field of green finance and economic development. Simultaneously, FDIs role in promoting environmental improvement is becoming a focal point, with an emphasis on using FDIs in eco-friendly projects to support the green and sustainable growth of economies globally.

3.10. Co-Citation Network

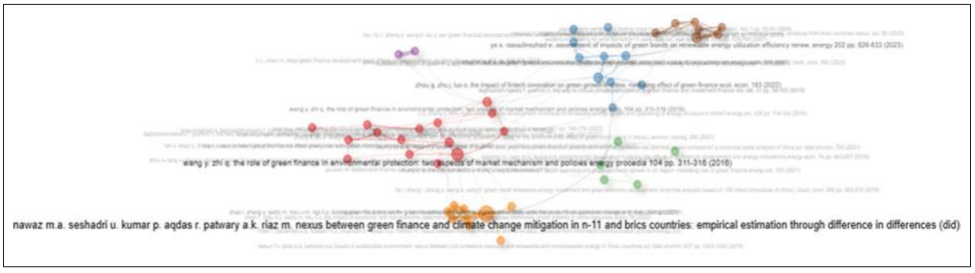
The frequency at which two papers are cited together is known as the co-citation frequency. The foundation of analysis is the idea that authors cite resources that they believe are crucial to the advancement of their studies. Co-citation analysis may be used to determine which group of articles has been cited the most in the present body of work. These works, which include foundational theories, creative introduction work, and methodological guidelines from the discipline, serve as the basis for the present study (Zupic and Čater, 2015).

3.10.1. Authors co-citation analysis

The purpose of author co-citation is to identify authors who are regularly mentioned with one another (Ribeiro et al., 2022). Six clusters that stand out from the others are revealed by the author's co-citation analysis, as shown in Figure 9.

Authors with similar co-citation profiles tend to appear in clusters, and the size of the circles in the maps reflects the frequency of citations. Closely linked authors often occupy the center of the "intellectual structure," whilst less closely related authors typically appear on the outside.

Figure 10: Papers co-citation analysis



Source: Biblioshiny

Table 11a: The top 10 articles with high betweenness

Articles	Betweenness
Influence mechanism between green finance and green innovation: Exploring regional policy intervention effects in China	179.65
The role of green finance in environmental protection: Two aspects of market mechanisms and policies	163.71
Can green finance development reduce carbon emissions? Empirical evidence from 30 Chinese provinces	146.37
Does green finance really deliver what is expected? An empirical perspective	94.42
Nexus between green finance, non-fossil energy use and carbon intensity: Empirical evidence from China based on a vector error correction model	73.36
The role of green finance in reducing CO_2 emissions: An empirical analysis	43.69
Impact of green finance on economic development and environmental quality: A study based on provincial panel data from China	41.17
Role of green finance in improving energy efficiency and renewable energy development	37.56
How does green finance affect green total factor productivity? Evidence from China	11.91
The way to induce private participation in green finance and investment	1.01

Source: Authors' compilation

Table 11b: The top 10 articles with high closeness

Articles	Closeness
The role of green finance in environmental protection: Two aspects of market mechanism and policies	0.003
Can green finance development reduce carbon emissions? Empirical evidence from 30 Chinese provinces	0.003
Influence mechanism between green finance and green innovation: Exploring regional policy intervention effects in China	0.003
Nexus between green finance non-fossil energy use and carbon intensity: Empirical evidence from China based on a vector error correction model	0.002
The role of green finance in reducing CO_2 emissions: An empirical analysis	0.002
Impact of green finance on economic development and environmental quality: A study based on provincial panel data from China	0.002
Does green finance really deliver what is expected? An empirical perspective	0.002
Role of green finance in improving energy efficiency and renewable energy development	0.002
The way to induce private participation in green finance and investment	0.001
How does green finance affect green total factor productivity? Evidence from China	0.001

Source: Authors' compilation

The similarity among the items is indicated by their closeness to one another (van Eck and Waltman, 2010). The degree of centrality, which may be further classified into betweenness centrality and closeness centrality, indicates the number of other authors who have co-cited together in an article (Fischbach et al., 2011). According to (Zupic and Čater, 2015), authors who possess high degrees of closeness centrality have the ability to connect with other writers in the network more quickly, and an author who exhibits a high betweenness centrality is considered to be a bridge between various research streams.

Table 12: The top 10 articles with high betweenness

Authors	Betweenness
Wang X	273.708
Huang J	219.875
Zhang Y	130.5
Sun Y	78
Wang Q	52.5
Liu H	51.875
Chen Z	40
Li H	40
Sun H	0
Gao J	0

Source: Authors' compilation

Table 13: The top 10 articles with high closeness

Authors	Closeness
Wang X	0.007
Huang J	0.007
Wang Q	0.006
Zhang Y	0.006
Liu H	0.006
Chen Z	0.005
Sun Y	0.005
Li H	0.004
Sun H	0.004
Gao J	0.003

Source: Authors' compilation

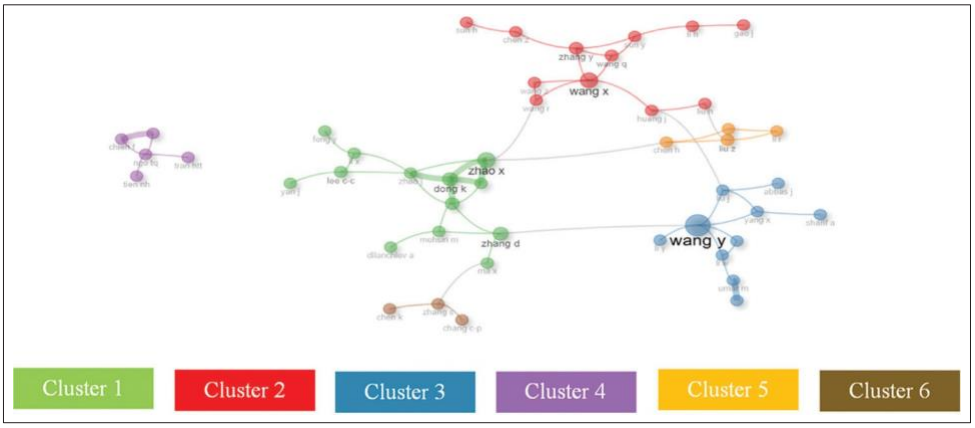
Table 10 illustrates the top 10 authors with the highest betweenness and closeness centrality, where scores for closeness centrality are the same for all. These are Wang Y, Lee Cc, Shahbaz M, Umar M, Su Cw, Wang X, Lin B, Razzaq A, He L, and Liu H.

3.10.2. Papers co-citation analysis

In terms of co-citation analysis of papers, two clusters are shown in Figure 10. The betweenness and closeness centrality metrics were also computed. The top 5 articles having the highest centrality betweenness are: (1) Influence Mechanism between Green Finance and Green Innovation: Exploring Regional Policy Intervention Effects in China (Irfan et al., 2022b), (2) The Role of Green Finance in Environmental Protection: Two Aspects of Market Mechanism and Policies (Wang and Zhi, 2016), (3) Can green finance development reduce carbon emissions? Empirical evidence from 30 Chinese provinces (Chen and Chen, 2021), (4) Does green finance really deliver what is expected? An Empirical Perspective (Khan et al., 2022), and (5) Nexus between Green Finance, Non-Fossil Energy Use, and Carbon Intensity: Empirical Evidence from China based on a vector error correction model (Ren et al., 2020). The top ten articles pertaining to the betweenness centrality metric are displayed in Table 11a.

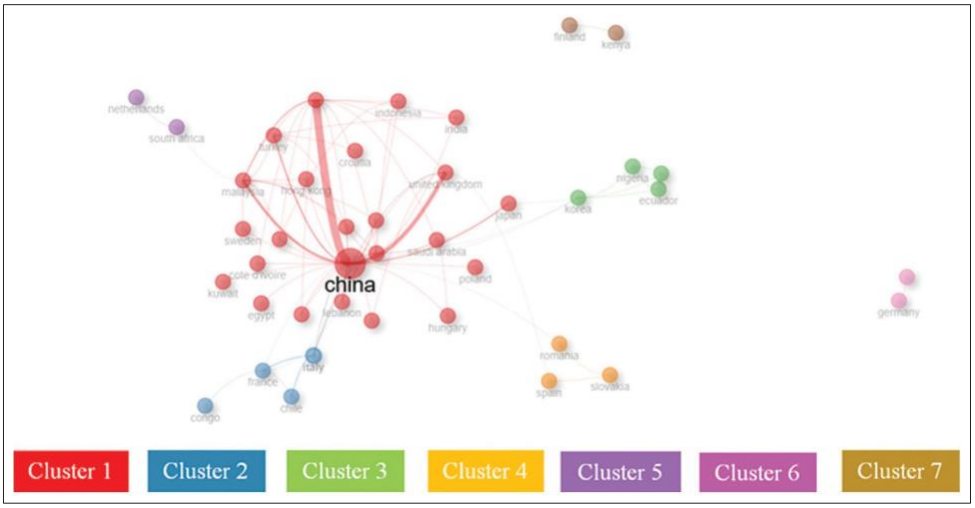
According to the closeness centrality scale, the following top 5 articles had the highest scores: (1) The Role of Green Finance in Environmental Protection: Two Aspects of Market Mechanism and Policies (Wang and Zhi, 2016), (2) Can Green Finance Development Reduce Carbon Emissions? Empirical Evidence From 30 Chinese Provinces (Chen and Chen, 2021), (3) Influence

Figure 11: Authors collaboration analysis



Source: Biblioshiny

Figure 12: Countries' collaboration analysis



Source: Biblioshiny

Mechanism Between Green Finance and Green Innovation: Exploring Regional Policy Intervention Effects in China (Irfan et al., 2022b), (4) Nexus Between Green Finance, Non-Fossil Energy Use, and Carbon Intensity: Empirical Evidence from China Based on a vector error correction model (Ren et al., 2020), and (5) The Role of Green Finance in Reducing CO_2 emissions: An Empirical analysis (Saeed Meo and Karim, 2022). Table 11b shows the ten articles with the highest closeness centrality values.

3.11. Collaboration Network

In addition to identifying the biggest research group in the region under analysis, the collaboration network displays research groups that are pursuing particular themes and their connections. Researchers, organizations, or nations are represented as nodes in a collaboration network, and the collaborative interactions among them are represented as edges or connections.

3.11.1. Authors' collaboration network analysis

Firstly, the collaboration among authors was examined. The collaboration network identifies research groups exploring particular themes and their relationships, as well as the largest group in the examined region (Siccardi and Villa, 2022). Figure 11 shows a total of 6 clusters of research groups for the analyzed topic, where the biggest group consists of 13 members (green), followed by 12 members (red), and 10 members (blue). The smallest research group includes only 3 members (brown). Furthermore, the graph illustrates the dearth of group collaboration. Similarly, Tables 12 and 13 represent the top 10 Authors with high betweenness and closeness centrality, respectively.

Table 10 shows that Wang X, Huang J, Zhang Y, Sun Y, Wang Q, Liu H, Chen Z, Li H, Sun H, and Gao J are the top 10 authors with high betweenness in the collaboration network.

Whereas Table 11 shows the top 10 authors with a high closeness, which include Wang X, Huang J, Wang Q, Zhang Y, Liu H, Chen Z, Sun Y, Li H, Sun H, and Gao J.

The prevalence of Chinese authors may indicate that research outputs and impacts are focused on China. The effect of the research might be increased if partnerships with the authors of other countries prove fruitful. These partnerships may act as a gateway for the study to be seen by more people worldwide.

3.11.3. Countries collaboration network

In bibliometric analysis, countries' collaboration network shows how co-authorship patterns of academic publications form connections across nations. In other words, a collaboration network refers to the connections among authors from different countries for a scholarly publication. This analysis reveals how frequently researchers from different countries collaborate on academic papers within a specific field or discipline. From Figure 12, it can be observed that China represents the largest node in the map. Besides being the most prolific in scientific publishing, it has also made the greatest number of collaborative networks with other countries.

Pakistan, the United Kingdom, Malaysia, the USA, Turkey, and Japan have been the strongest collaborators of China. India is also one of the top 10 countries with high betweenness and closeness. The network shows 7 clusters, of which the red one is the most densified. It includes several countries from different continents such as Asia, South America, Europe, North America, etc. The countries have collaborated more with one another in this cluster than in any other cluster.

The second cluster with 4 members, i.e., Italy, Congo, France, and Chile, also shares connections with each other in the same cluster. Of these 4 members, only two (Italy and France) share connections with other countries in the red cluster. Italy (in the blue cluster) shares the collaboration with China, the UK, and the USA, whereas France has collaborated with Lebanon and China. The third cluster (green) also consists of four member countries, i.e., Ecuador, Slovenia, Nigeria, and Korea, where only Korea has collaborated with China, the USA, and Japan in the red cluster. Romania, Slovakia, and Spain are included in the fourth cluster (orange) where Romania and Spain have collaborated with China and the USA, respectively. The purple cluster, which includes the Netherlands and South Africa as its member countries, also collaborated with one member country of the red cluster, i.e., Malaysia.

There are strong collaboration networks among the displayed countries (Figure 12) since almost all the countries in the map are linked in the network except for two clusters, i.e., pink and brown, which include Germany and Austria, and Finland and Kenya. These countries are located in the outermost areas of the map, which shows that they are least productive in this discipline and consequently have established weaker international collaboration networks.

Since economic development and environmental sustainability is a global concerns, this collaboration needs to be expanded to include additional countries in the clusters. Additionally, a more thorough understanding of cross-cultural management is also required.

4. CONCLUSION

In the past few decades, the growth of the economies has accelerated dramatically. As a result, over-exploitation of forest resources has resulted in environmental degradation and pollution, making it a severe task to safeguard the ecosystem as soon as possible while also preventing a number of detrimental effects on human health. This has led governments across the globe to frame new economic policies aimed at making better use of existing environmental resources. Green finance is one such medium that ensures the growth of the economies, along with better environmental outcomes. Green finance provides financial assistance and direction for the development of a green economy, including clean energy firms and high-tech pollution control equipment manufacturers. This approach enhances the financial system by addressing environmental pollution from all angles. The objective of this study was to analyze current trends and developments in the realm of green finance and economic development by utilizing a bibliometric approach. By analyzing 289 relevant publications and visualizing certain key factors, we can gain a better understanding of this subject matter through various bibliometric analyses. According to a keyword analysis of the literature, green finance and economic development should be viewed as an interdisciplinary study issue that covers and deals with sustainability, climate change, policies, clean energies, financial development, etc. Scholars from the Republic of China presently dominate the field of green finance and economic development research, as the result of the country of origin demonstrates. The majority of publications in this field are published in policy journals or journals that concentrate on environmental/climate changes; mainstream finance or economics journals seldom ever publish papers in this field. Similarly, Chinese institutions also dominate other countries in terms of producing literature in the relevant field. The result of the co-citation analysis also reveals that the authors from China are highly co-cited as they exhibit higher closeness and betweenness centrality. Concerning the social structure of the research field, Pakistan, the USA, the UK, Turkey, and China are the main collaborating countries.

By providing a thorough bibliometric analysis, this study bridges a gap in the literature and aids in advancing the knowledge of researchers on the relationship between green finance and economic development. Based on the findings of the study, the significance and implications of the study can be presented as follows: First, governments worldwide should formulate policies that may unite their nations in the battle against climate change and open the door for future growth, as the study's results indicate that a concentrated effort must be directed toward coordinated development. Second, by offering a thorough summary of the origins, developments, and current state of green finance research pertaining to economic development, this paper will be beneficial to potential researchers as this will highlight how this field is distributed across subject areas, journals, countries, institutions, and authors while providing a synthesized summary of the definitions, perspectives, and research trends currently found in it. This helps researchers identify possible directions for future research. Third, the study illuminates that countries like India, the USA, the UK, Pakistan, Malaysia, etc. need to streamline the use of green finance in their economic development mechanism by taking guidance from China for their research and development programs. Fourth, countries should collaborate more on the concerns of green finance and economic development, as this is a global concern in the current era of sustainability.

Although this study adds to the body of knowledge on this topic, but being the first thorough mapping of the research field, it has several limitations that should be noted through bibliometric analysis, along with some potential for future research. Because the "Scopus" database was the only source used for data gathering, papers and other kinds of materials that were indexed by other platforms, i.e., Web of Science, EBSCO, Google Scholar, PubMed, etc., were left out. In the future, these databases may also be used to extract literature to provide a more comprehensive picture of the topic. Further, the finding has significance for future research to identify the key elements that make China the nation that contributes the most to scientific studies on green finance and economic development. Moreover, it offers insight into unexplored fields of research in the current area. As proof, addressing new technology advances is one of the greatest ways to minimize climate change; nevertheless, this field of study is not given enough attention by connecting economic development to green financing. Additionally, we urge that future research take this aspect into account when examining the problem of green financing and economic development globally. Lastly, it would be ideal for future research to consider the current state of each nation with regard to capital contributions and the mobilization of green finance in order to facilitate economic development, as these are the most important factors that can affect the degree of development of a nation.

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