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FINANCING GREEN ENERGY IN DEVELOPING COUNTRIES: A BIBLIOMETRIC REVIEW OF GLOBAL RESEARCH TRENDS

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Abstract: *This study (financing green energy in developing countries 2008-2026) provides a bibliometric analysis of green energy financing research in developing countries between 2008 and 2026. Using data from the Scopus database analyzed via Bibliometrix and Biblioshiny, publication trends, leading institutions and authors, and major developments were examined. Results show a significant increase in research output since 2020, which corresponds to a greater global interest in financing sustainable energy. Core journals (Environmental Science and Pollution Research; Resources Policy) dominate the field. China and India are the largest contributors to research output. Major clusters of research identified through thematic analysis include: green finance instruments, policy and regulatory frameworks, financial barriers, deployment of renewable energy, and emerging solutions using fintech. Disparities in global research contribution and collaboration are highlighted with developing regions showing less representation than others. Despite improvements in financing mechanisms (e.g., green bonds; blended finance), challenges to attracting investment remain (e.g., high capital costs; policy uncertainty; weak institutions). This effort contributes a map of the intellectual structure of the field and gaps in knowledge to support policymakers, researchers, and practitioners working towards a rapid transition to green energy in developing economies.*

Keywords: Green Energy Financing; Developing Countries; Renewable Energy; Green Finance; Bibliometric Analysis; Climate Finance; Blended Finance; Sustainable Development;

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Energy Transition; Policy Frameworks

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Introduction

The financing of green energy in developing countries is now seen as key area of focus within the global framework for climate change, energy security and economic development that is occurring on a global scale. As the world deals with the increasing effects of global warming, it is no longer an option to move from fossil fuels to alternative energy systems; rather, it is an imperative that this type of transition occurs. Developing nations will play an important role in this transition as they will represent a large portion of future energy consumption as they continue to grow rapidly in terms of population, urban growth and industrial growth. At the same time, developing countries represent some of the most vulnerable countries when it comes to being impacted by climate change so using green energy presents not only a necessity from a development standpoint, but also from an environmental standpoint as well (IEA, 2021).

Despite being seen as an important source of long-term economic and environmental gains through the use of renewable sources like photovoltaic panels, wind turbines, hydroelectric dams, and biomass energy; investing in green energy still involves significant initial costs. The price of renewable technologies has dropped dramatically over the last decade; however, financing limitations that affect their widespread adoption in developing nations are still significant. Reasons include but are not limited to; lack of access to capital, inadequate financial systems, weak regulations, and perceived high risk associated with making investments in emerging markets (Bhattacharya et al., 2016 and Polzin, 2017). Overall, as the financing gap between greens energy projects continues to grow wider, the possibility that the world's energy landscape will transition forward as fast or as extensively has declined significantly.

The main challenge to financing renewable energy projects is due to the difference between the return on investment expected by private investors versus what exists in reality within developing countries. The initial capital outlay for a renewable energy project is usually high, and with long pay-back periods, this deters participation by private sector investors, especially if the country is politically unstable, has high currency volatility, and/or has an uncertain policy framework (OECD, 2018). In addition to the factors above, many developing countries do not have sufficient institutional frameworks or a transparent regulatory framework, which is needed to attract long-term investment. The lack of well-defined and delivered policies that provide incentives for renewable energy projects, coupled with the low credit-worthiness of local institutions, only adds to the wariness of investors.

For many years, the role of public finance was to support green energy initiatives in developing countries. Governments worked with multilateral development banks and international organizations on programs that provided direct subsidies, grants, and concessional financing for renewable energy to incentivize its use. The World Bank, regional development banks and other climate-focused funds have provided critical financial support and de-risking support to private-sector investors through program and project-level financing (UNFCCC 2020). Nevertheless, the

scale of investment required is far too large to rely solely on public-sector resources. The IEA estimates that trillions of dollars in clean-energy investments will be needed to meet the world's climate goals, much of which will need to be directed toward the emerging and developing economies.

In developed and developing countries, many innovative financing methods have appeared to be a breakthrough solution to meeting the investment gap. For instance, green bonds, blended finance, climate funds, and private-public partnerships (PPPs) have all gained traction as ways to mobilise funds for renewable energy projects. Green bonds are one of the fastest-growing types of financial markets globally and are designed to allow governments and corporations to raise funds for environmentally sustainable projects (Climate Bonds Initiative, 2022). Likewise, blended finance provides an approach to attract institutional investment (OECD, 2018) by combining public and private financing, which can lower the risk of investment while attracting more capital to developing markets. Conversely, the effectiveness of these instruments varies across nations. Their effectiveness will depend on individual markets, along with geographic and regulatory barriers, and thus will have a large impact on how successful these financing mechanisms will be for different regions.

In this context, we conduct a bibliometric analysis looking at the literature of financing green energy in developing countries between 2008 and 2026. Using quantitative methods can help analyse publication trends, citation patterns, leading authors, key journals, and thematic development so that we can create an intellectual map of the development of this body of knowledge. We also examine research clusters, dominant financing mechanisms, and contributions by region to identify knowledge gaps where more research is needed. This bibliometric analysis provides a comprehensive look at how the academic discussion around financing green energy has changed and lays the groundwork for future research. Additionally, this research provides policymakers, practitioners, and researchers with information they need to make informed decisions on how to accelerate the transition to sustainable energy in developing economies.

Inordertoaccomplish this study's objectives, a series of structured research questions wascreated in order to Properlyassessfinance for Green Energyin Developing Economies. These questions focus on assessing how research has changed over time, structurally, intellectually, and thematically. Bibliometric techniques willbe applied using R-based tools such as the Bibliometrix package toperform performance analysis (to assess the performance level of researchers and/or institutions), science mapping (to locate the geographical areas and/or disciplines that have published articles related to Green Energy financing) and thematic evolution (to determine how thematic areas have progressed over time). This will be done to create a completeview of the Green Energy financing research area. Following research questions have been framed:

Core Research Questions

RQ1: In terms of publication trends, how have publications on green energy financing for developing nations changed between 2008 and 2026?

RQ2: What are the most important authors, institutions, and nationsactivein this realm of research and howdoeseachmeasureupinterms of citation metrics?

RQ3: What are the most prolific and influential journals and sources related to green energy financing research in a developing economy?

Science Mapping & Network Analysis
RQ4: What are the major intellectual structures of the field as revealed through co-citation and bibliographic coupling networks?
RQ5: How are collaboration patterns structured among authors, institutions, and countries in this domain?
RQ6: What are the key keyword co-occurrence networks, and how do they reflect the conceptual structure of green energy financing research?

Thematic Evolution & Trends
RQ7: What are the dominant and emerging research themes in financing green energy in developing countries over time?
RQ8: How has the thematic evolution of the field progressed across different time periods (e.g., 2008–2015, 2016–2020, 2021–2026)?
RQ9: Which topics have gained prominence recently (e.g., green bonds, climate finance, blended finance, ESG investing), and which areas remain underexplored?

Impact & Knowledge Gaps
RQ10: What are the most highly cited documents in this field, and what key insights do they provide regarding financing mechanisms and policy implications?
RQ11: What research gaps exist in the current literature, particularly in the context of developing countries' financial constraints and institutional challenges?
RQ12: How can future research directions be shaped based on the bibliometric findings to strengthen green energy financing strategies in developing economies?

Literature Review

Transitioning to Clean Energy has moved to the forefront of international dialogues on Sustainability with respect to the developing country that has both inadequate energy supplies and vulnerability to climate change. A lack of financing continues to be one of the primary barriers to clean energy adoption for these economies, due in large part to the limited domestic capital, institutional capacity, and risk mitigation framework of these economies. Recent research has illustrated how fast the landscape for Green Financing is evolving and demonstrates how it can be utilized to expedite the adoption of Renewable Energy; however, it also identifies many structural obstacles that developing countries face in the pursuit of developing a Clean Energy Economy.

There exists an increasing number of investigators who find that there is a distinct connection between green finance and renewable energy growth. There is clear evidence whereby financial tools such as green bonds, concessional loans, and climate funds enhance the rate of growth of renewable energy infrastructure investments. For example, Chen et al. (2024) find that green finance has a positive impact on renewable energy growth in developing nations as it relates to the support provided through banks and through the creation of capital markets. Additionally, Nepal et al. (2024) present the argument that international green financing reduces the lack of financing and drives low-carbon transitions to energy in poor countries where there is little or no financing available domestically. These studies demonstrate that the availability of external financing is critical in order to facilitate the expansion of renewable energy.

Literature identifies the major financial instruments that drive investments in renewable energy with the highest level of credibility/comparability being the green bond, which has

increasingly become an avenue for raising money through global capital markets. A review of existing literature shows that green bonds are leveraged to help fund renewable energy projects while simultaneously lowering firms' costs of capital for being involved in the production of green energy (Loiola et al., 2025). Additionally, blending public and private sector capital has also been regarded as an important means of reducing risk associated with investments in developing countries through the use of grants, guarantees and concessional financing offered by public institutions as an incentive to attract private sector investors and thereby overcome the issues related to market failure and perceived risk.

Important factors are also examined in the literature regarding the role of policy and institutional frameworks supporting green energy financing. Studies indicate that stable regulations, transparent governance, and supportive policies are crucial in driving investment flows. Mudalige (2023) did a systematic review of the literature on factors impacting the efficiency of green finance to stimulate green growth by identifying three key attributes: (1) policy support; (2) level of economic development; and (3) technological innovation. In developing countries, there is often a lack of well-developed institutions and inconsistency in the middle of policies that cause investors to hesitate and thereby highlights the need for reforms to improve investor confidence and reduce the transaction costs associated with obtaining financing.

Technological development, specifically digitalisation has also been acknowledged as an enabler of financing for sustainable development through numerous studies. Recent empirical research indicates that advances in technology and the use of digital technologies can increase the availability and efficiency of capital allocation to renewable energy sectors. Research by Nepal et al (2024) indicates that the application of digital technologies can increase the effectiveness of green financing for the energy transition process through more accessible financial services and reduced information asymmetries. As a result, collaborations between the digital finance sector and the green energy sector represent a new avenue of research, particularly with the advent of new fintech tools such as crowdfunding platforms and blockchain-based systems for trading energy.

Even with all of the progress made in renewable technology, developing nations still face many obstacles when it comes to financing their development using renewable energy sources. The most commonly heard issue is the high perception of risk that investors have toward renewable energy projects. Political risk in these developing regions; volatility in currency exchange rates; and poor credit ratings create a high cost of capital and thus make the private investor less likely to invest. In addition to the previous mentioned issues, underdeveloped financial markets result in limited access to long-term financing needed for capital-intensive projects. Rabbani et. al. (2025) show the disparity in financing sustainable energy among developing and developed regions and indicate that, when analyzing the total financing distributed to renewable energy worldwide, the developing regions do not receive enough finance given the level of need they have for financing renewable energy development.

Micro-level research emphasizes the importance of small and medium enterprises (SMEs) and start-ups to promote green innovation at the micro-level, which can be understood through macro-level financing mechanisms. According to Mukherjee et al. (2024), obtaining early-stage financing is essential for green start-ups because they encounter many challenges when attempting to secure traditional funding. As a result, venture capital, impact investing and publicly backed funding programs are being increasingly used to facilitate innovation in companies developing renewable energy technology.

New systematic reviews show an emphasis on emerging areas in green energy financing. These are investing using Environmental, Social, and Governance (ESG) criteria; developing carbon markets; and using climate risk disclosures to change financing. An increasing emphasis is also

being placed on achieving equal access to financing, so that resource-poor, marginalized communities in developing countries can share in the benefits of the energy transition.

Methodology

The first phase of bibliometric analysis was to identify suitable databases for this type of research; in this case, research data came from the Scopus database and included articles published between 2008 and April 2026. According to Chadegani et al., Scopus is one of the most comprehensive and available citation databases since it has a large number of abstracts and scholarly literature. In another study, Zhao and Strotmann (2008) found that Scopus has approximately 60% more coverage than the Web of Science database.

The terms utilized to establish the framework of this analysis are "financing", "green energy" and "developing countries" so that sufficient literature could be retrieved, three independent searches were done on individual keywords for each of these terms. The initial search included various combinations of keywords denoting various aspects of the concept of green energy. The second search only included combinations of keywords associated with the idea of financing green energy. This procedure allowed for all possible combinations of keyword terms being captured within both searches.

The first search identified an initial count of 190. After using filter(s) for Subject Areas: Business, Management & Accounting; Environmental Science; Social Sciences; Energy; and Earth & Planetary Sciences, the total count was reduced to 182 Documents. Then further refining was performed using Document Types (research articles, review papers, books, book chapters and conference papers) resulting in an overall total count of 173 Documents available for Analysis.RStudio was utilized as a statistical computing environment to conduct the analysis. The Bibliometrix package was used for bibliometric analysis in R. R provides an integrated ecosystem with multiple open-source libraries, algorithms, and advanced graphical capabilities for conducting various types of data analyses and visualizations.

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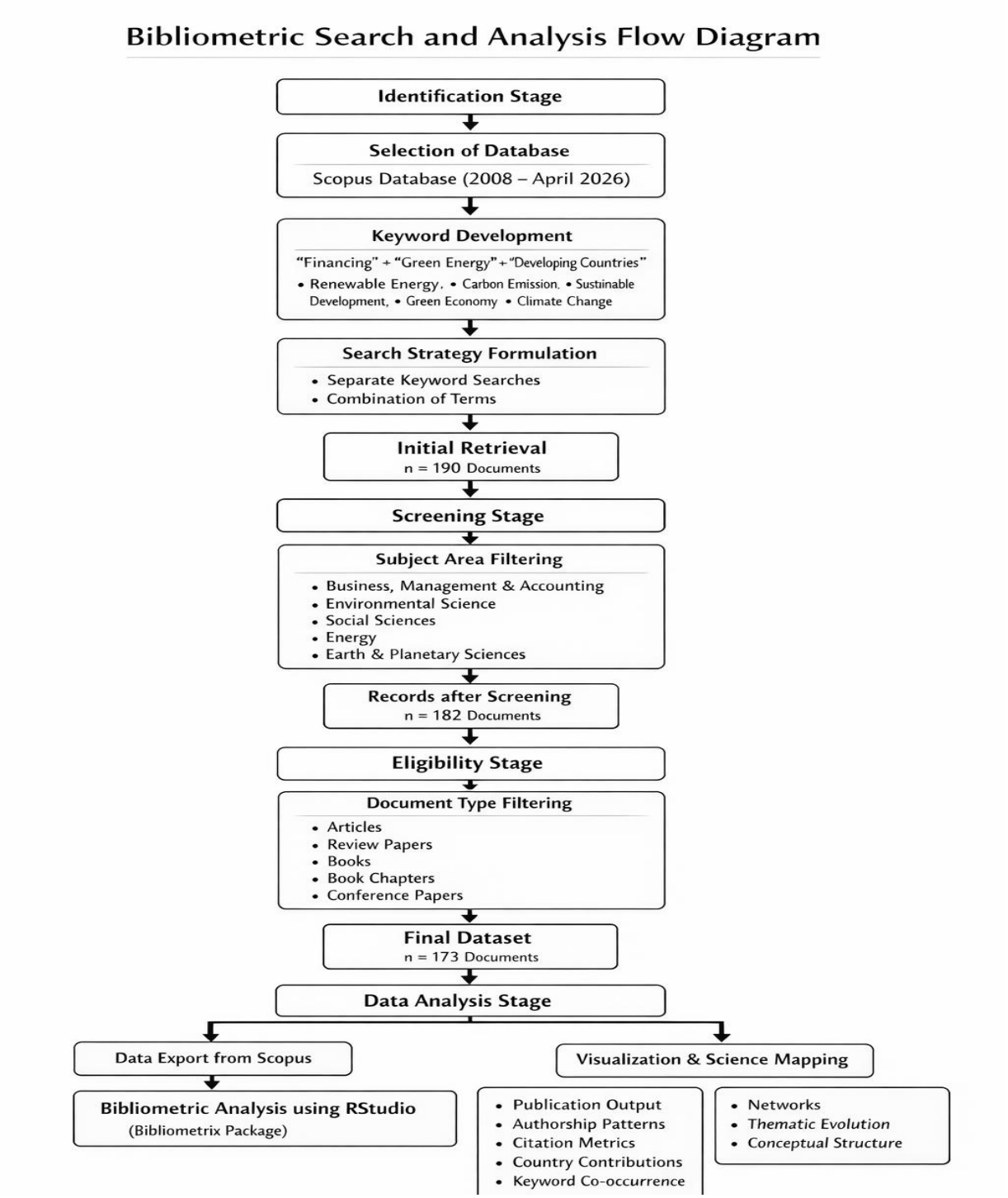

Figure 1. Search and Analysis Flow Diagram

Analysis and Findings

The researchers retrieved bibliometric data from the Scopus data base inorder to address their research questions,which were subsequently analyzed using Biblioshiny, the web interface of the Bibliometrix package in R. Scopus was chosendue to its international and multidisciplinary scope of coverage, with respect to peer-reviewed articles, conference proceedings and book series. The

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factthatallof the articles are indexed consistently makes it arobust source for conducting comprehensive bibliometric analyses based on standardised metadata.

Additionally, Biblioshiny allows for an easy-to-use and effective analytic approach to perform a systematic evaluation of large data sets, reducing the need for specialized programming skills to analyze the datasets. The tool can be utilized to carry out numerous bibliometrics techniques, including: performance analysis; science mapping techniques such as co-authorship networks; co-citation analysis; and keyword co-occurrence. These functions will allow researchers to gain more in-depth insight into the intellectual structure of the research domain, the developments in the theme over time, and collaborative patterns.

The incorporation of Scopus as a data source and Biblioshiny as an analytical tool provided for methodological rigor, transparency, reproducibility, thus improving the reliability and validity of the study's conclusions.

Annual Scientific Production

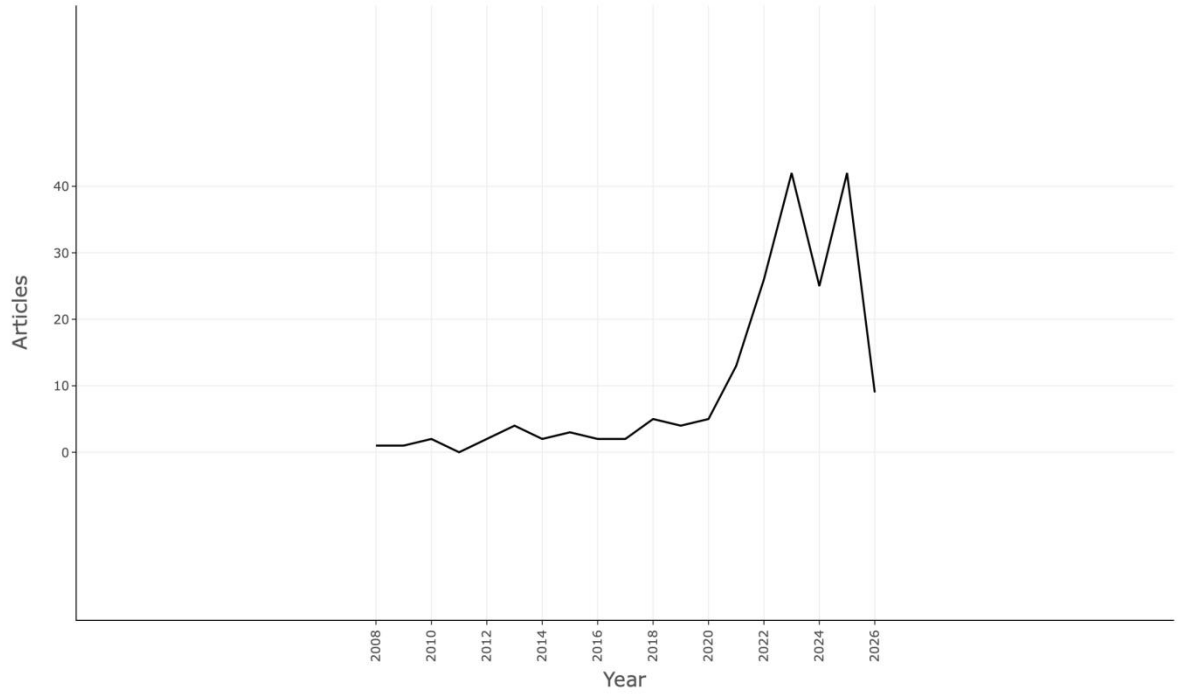

Figure 2. Year Wise Contribution

The figure indicates a slow and stable publication trend from 2008 to 2018, followed by a sharp increase after 2020. Peak output occurs around 2023–2025, showing growing research interest, while the drop in 2026 likely reflects incomplete data rather than a real decline.

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Average Citations Per Year

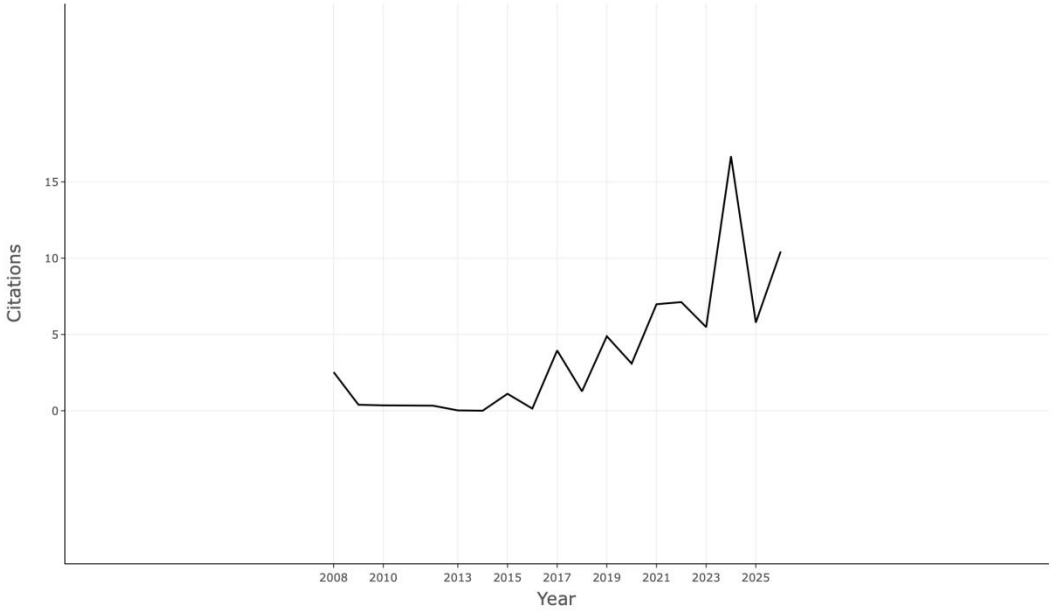

Figure 3. Year Wise Citations

The figure indicates that over time the average number of citations has continued to rise. Average citation counts were low and stable until about 2015, after which they began a steady upward trend that peaks sharply around 2024. Although there are some minor fluctuations in trends, there has been a general increase in research's visibility and impact in recent years.

Most Relevant Sources

Table 1. Most Relevant Sources

Sources	Articles
ENVIRONMENTAL SCIENCE AND POLLUTION RESEARCH	13
RESOURCES POLICY	10
SUSTAINABILITY (SWITZERLAND)	6
RENEWABLE ENERGY	5
ENERGY POLICY	4
ECONOMIC ANALYSIS AND POLICY	3
FINANCING OF SUSTAINABLE DEVELOPMENT GOALS (SDGS): CHALLENGES AND OPPORTUNITIES	3
INTERNATIONAL MULTIDISCIPLINARY SCIENTIFIC GEOCONFERENCE SURVEYING GEOLOGY AND MINING ECOLOGY MANAGEMENT, SGEM	3
JOURNAL OF CLEANER PRODUCTION	3
CLIMATE POLICY	2

Based on the distribution of outputs, we can conclude that much of the output from academic research is published in a handful of major journals. The publication with the most total outputs of any journal is Environmental Science and Pollution Research, followed by Resources Policy and Sustainability. Some of the other journals with a focus on sustainability, energy and environmental policy such as Renewable Energy, Energy Policy, and Journal of Cleaner Production also indicate a significant concentration on these topics. As such, while this field appears to be an interdisciplinary area of research, the majority of published material appears to be focused in environmental and energy-focused publication.

Core Sources by Bradford's Law

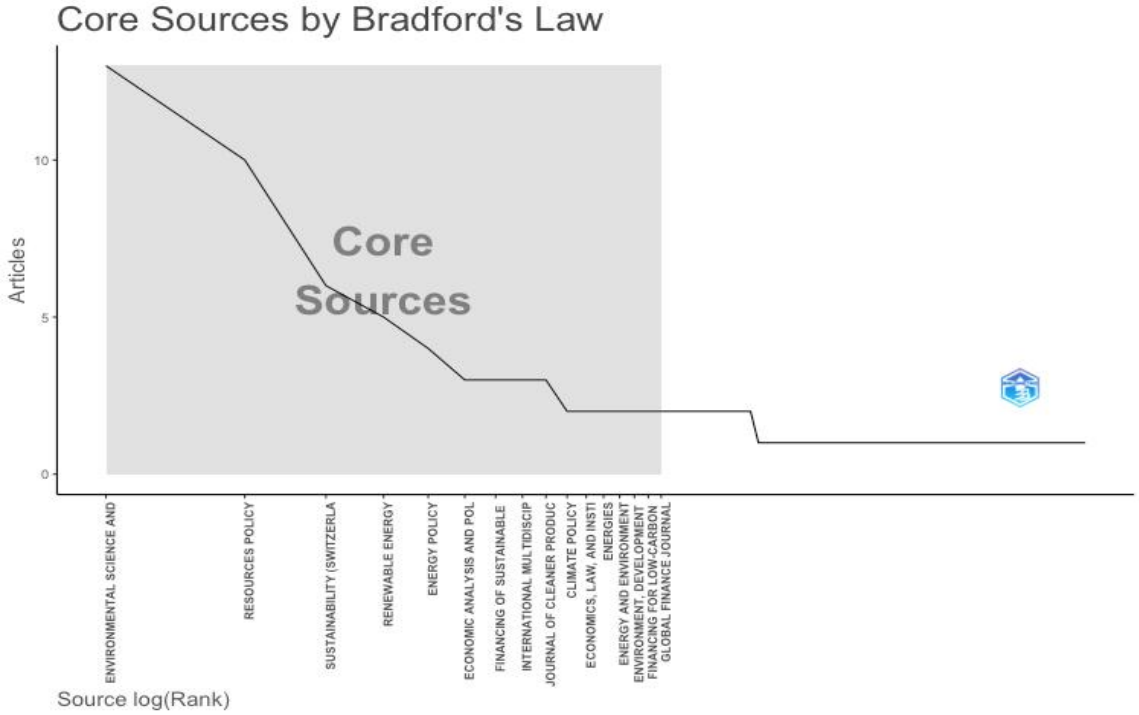

Fig. 4. Core sources by Bradford's Law

The figure shows that Bradford's Law demonstrates how small groups make up most of the publications and how those same publications are distributed among other smaller groups of journals or less productive. Therefore, this demonstrates that there is a clear core to those journals that are most influential to the field because most of the articles published in plurality are published through the same core journals. Some important core journals are Environmental Science and Pollution Research; Resources Policy; Sustainability (Switzerland); Renewable Energy; and Energy Policy.

Source's Production Over Time

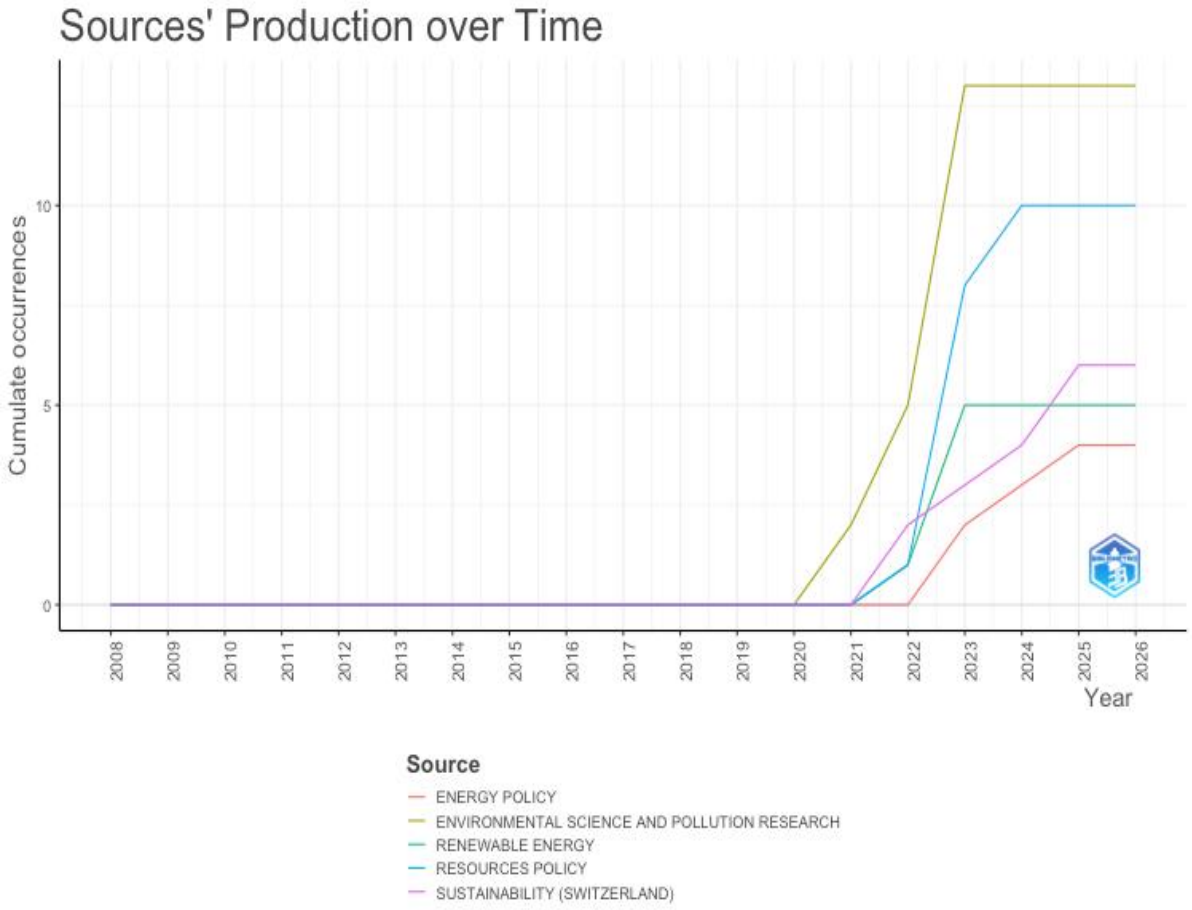

Figure 5. Source's Production Overtime

According to the data above, major journals began publishing significantly from late 2020, and have seen an exponential increase in published research since then. Environmental Science and Pollution Research and Resource Management published the greatest amount of research, followed by Sustainability and Renewable Energy, with less of an increase in Energy Policy Publications. Overall the trend indicates that there was recently an extremely fast increase in output from the major sources.

Most Relevant Author's

Table 2. Most Relevant Author's

Authors	Articles	Articles Fractionalized
NA NA	6	6
LIU Y	5	1.916666667
TAGHIZADEH-HESARY F	5	1.7
SARKER T	4	1.272222222
LI Y	3	0.833333333

LIU Z	3	1.033333333
MOHSIN M	3	0.65
RASOULINEZHAD E	3	0.95
ALI S	2	0.5
ARORA R	2	1

According to the table, a particular group of authors has provided an appreciable amount of their output or the contributions to the body of literature. This can be seen reflected in the overall author counts in the column labelled NA (not assigned), which has the highest number of authors and author counts; however, both total and fractionally total, the most productive authors, are Y Liu and F Taghizadeh-Hesary. Many other authors also contributed substantial amounts (but not to the same extent) such as T Sarker and Z Liu. The overall data show moderate research productivity concentration; therefore, while few authors contributed the majority of research productivity to this study, there were also many authors who collaborated and/or did not provide their respective total number of fractionally total authorship (or contribution) scores.

Most Relevant Affiliations

Table 3. Most Relevant Affiliations

Affiliation	Articles
TOKAI UNIVERSITY	7
GRIFFITH UNIVERSITY	5
JIANGSU UNIVERSITY	5
CITY UNIVERSITY OF MACAU	4
FINANCIAL UNIVERSITY UNDER THE GOVERNMENT OF THE RUSSIAN FEDERATION	4
GHAZI UNIVERSITY	4
TIANJIN UNIVERSITY OF COMMERCE	4
UNIVERSITY OF SOUTHERN QUEENSLAND	4
FUDAN UNIVERSITY	3
KARAGANDA ECONOMIC UNIVERSITY OF KAZPOTREBSOYUZ	3

According to the table, only a small number of universities are producing a majority of research products. The first university in rank according to productivity rankings is Tokai University, the second university in rank according to productivity rankings is Griffith University, and the third university in rank according to productivity rankings was Jiangsu University. There are also many other universities producing a large volume of research products, including City University of Macau, Financial University under the Government of the Russian Federation, Ghazi University, Tianjin University of Commerce, and the University of Southern Queensland. Overall, it appears that there are many universities producing good amounts of research worldwide and that they are working together within the field of study producing collaboration research products.

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Corresponding Author's Countries

With the greatest number of published articles and collaborations between multiple countries, China is at the very top for the most number of papers published globally. India is second with lots of articles, but most of them were published as stand-alone events. Other countries like the UK and Germany have ended up with fewer articles published overall, but had much more international collaboration than others (e.g., Iran, Japan) generally emphasize domestic collaborations. Globally, the countries that are the highest volume producers frequently are those with the largest total volume; countries with fewer volumes tend to rely on global collaborations for their volume production.

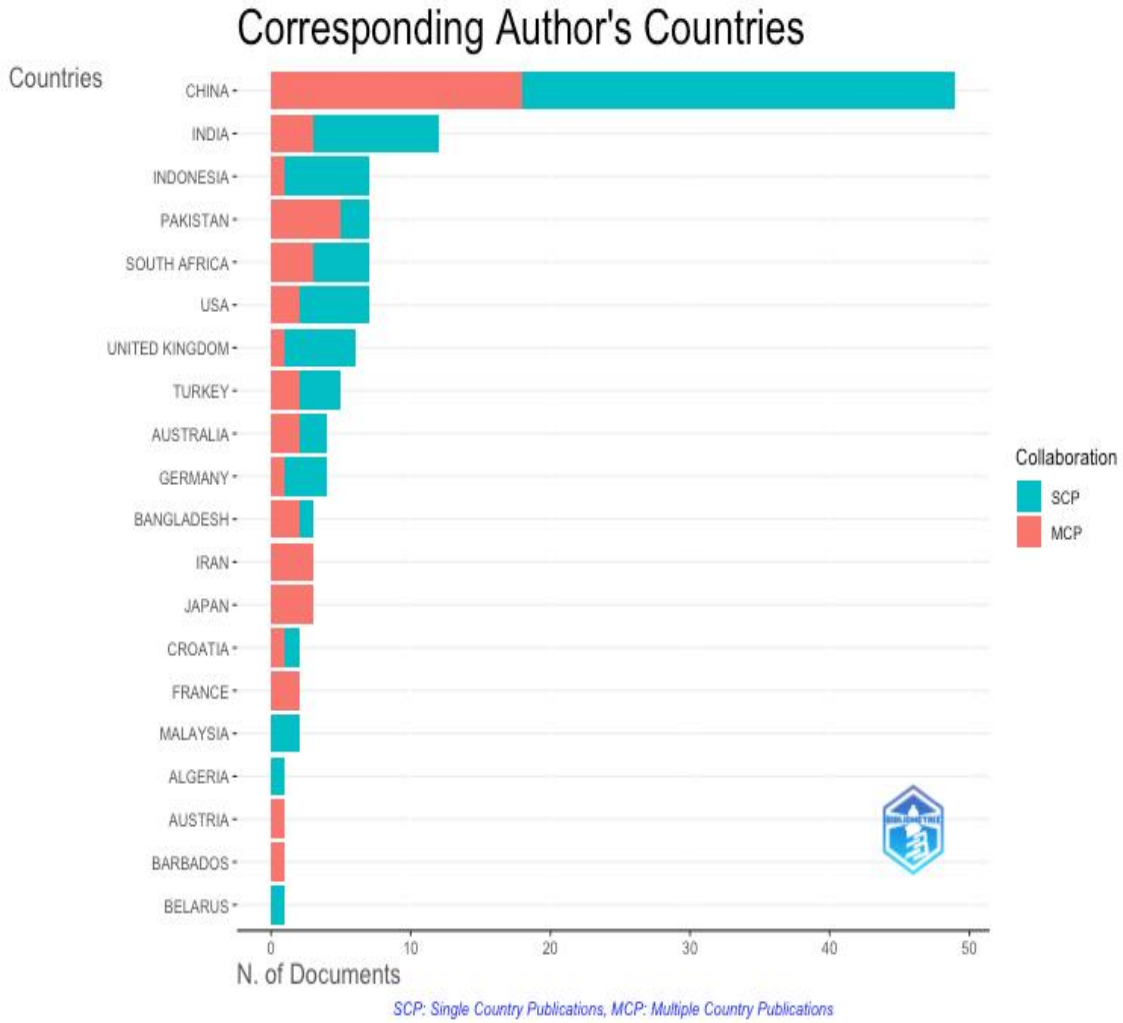

Figure 5. Corresponding Author's Countries

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Country Specific Production

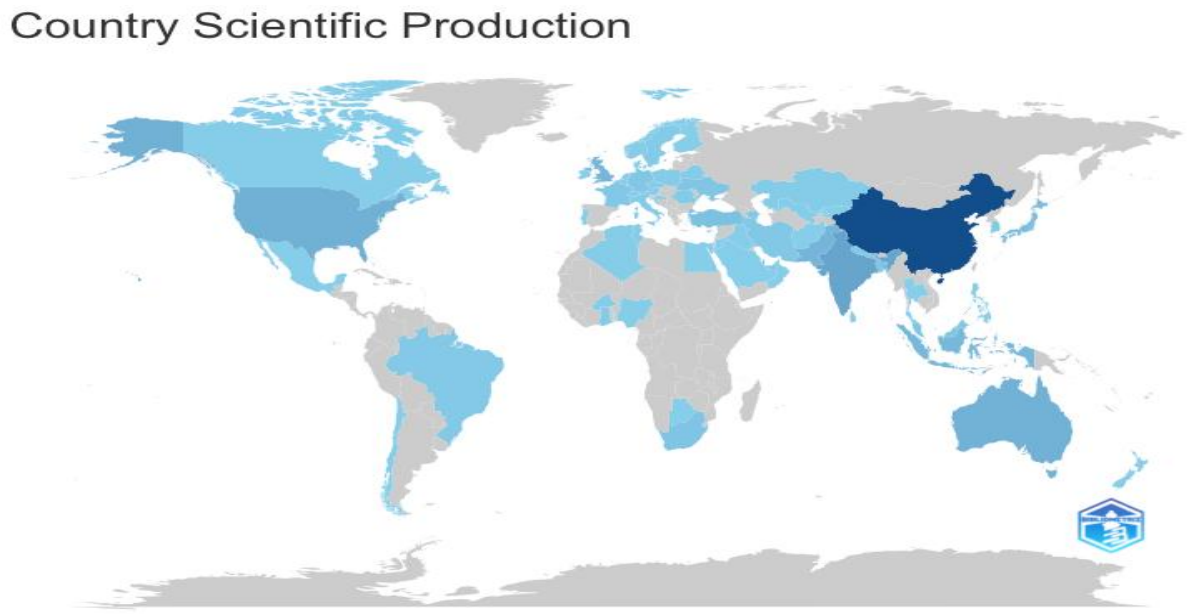

Figure 6. Country Specific Production

Globally, China produces the most scientific research, followed closely by other countries such as India, the United States, some European nations (notably western Europe). There are moderate amounts of output coming from some other countries like Australia, Brazil, and parts of the Middle East, but compared to Africa and many developing areas, scientific output is low across these regions and the majority of research production is concentrated in very few countries (major economies), indicating a large discrepancy between developed and developing nations when it comes to their relative levels of science productivity.

Most Cited Countries

Table 4. Most Cited Countries

Country	TC	Average Article Citations
CHINA	2053	41.9
PAKISTAN	486	69.4
INDIA	444	37
INDONESIA	331	47.3
AUSTRALIA	235	58.8
UNITED ARAB EMIRATES	112	112
MEXICO	80	80
JAPAN	75	25
CZECH REPUBLIC	72	72
SOUTH AFRICA	62	8.9

The evidence indicates that the number of papers published and the number of papers which are cited are not the same. Although China produces many papers, their citation impact is moderate. Other countries such as the United Arab Emirates, Mexico, and the Czech Republic have a large number of papers with high average citations which means they have a strong research impact. The amount of research that India produces is moderate with a relatively lower citation impact. Japan and South Africa produce fewer papers and have the lowest average citation per paper. Overall, the amount of published research does not always equate to the amount of impact that research has on society.

Most Global Cited Documents

Table 5. Most Cited Countries

Paper	Total Citations	TC per Year
FILONCHYK M, 2024, SCI TOTAL ENVIRON	735	245
NAWAZ MA, 2021, ENVIRON SCI POLLUT RES	332	55.33333333
KUMAR S, 2025, ANN OPER RES	287	143.5
FANG W, 2022, RENEW ENERGY	261	52.2
ALLAM Z, 2022, RESOURCES	166	33.2
MA M, 2023, RENEW ENERGY	128	32
AWAWDEH AE, 2022, CHINA FINANCE REV INT	112	22.4
SHABIR M, 2022, ENVIRON SCI POLLUT RES	104	20.8
CHEN JM, 2024, HELIYON	95	31.66666667
BARBIER EB, 2020, WORLD DEV	91	13

The data shown in the table illustrates the citation impact of more current papers as being higher. For example, Filonchyk (2024) has the highest number of total citations as well as the highest rate of citations per year, indicating that it is rapidly gaining influence. Kumar (2025) also has the high rate of annual influence, though it is a newer publication. In contrast, earlier publications such as Barbier (2020) have lower rates of annual citation, indicating that these papers are losing momentum as time progresses. In summary, it appears that the more recent the publication, the more quickly its citations have accumulated due to an increase in research interest and relevance in this area of study.

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Most Frequent Words

Table 6. Most Frequent Words

Words	Occurrences
renewable energy	42
sustainable development	41
green economy	38
developing countries	37
investments	31
alternative energy	29
climate change	29
green finance	29
developing world	25
finance	24

The frequency of keywords indicates that there is an increasing amount of research being done on renewable energy and sustainable development which connect closely to both a green economy and climate change. There are also many occurrences of the terms such as "green finance", "investments", and "developing countries" where most of this research has a strong focus on financing the transition towards cleaner energy, especially regarding developing areas. In general, the research in this area focuses on the relationship between sustainability, finance, and clean energy.

Word cloud

Figure 7. Word cloud

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The Word Cloud shows Sustainable Development as a major theme that can relate closely to renewable energy, green economy, and climate change. The Word Cloud also represents the transition away from the use of fossil fuels to the use of clean energy and the means to invest in and finance green initiatives, particularly in developing countries. In conclusion, the Word Cloud gives an overall picture of how economic growth, environmental policies and transition of energy are interrelated.

Trend Topics

Table 7. Trend Topics

Term	Frequency	Year (Q1)	Year (Median)	Year (Q3)
mitigation	5	2017	2021	2022
energy efficiency	17	2021	2022	2023
financing	9	2017	2022	2023
emission control	6	2019	2022	2023
renewable energy	42	2022	2023	2025
sustainable development	41	2023	2023	2025
green economy	38	2022	2023	2025
developing world	25	2023	2024	2025
sustainability	15	2023	2024	2025
green financing	13	2023	2024	2025

According to the data in Table 7, there has been a noticeable evolution in the trends of this type of research over time. The data suggests that the early topics of conversation (mitigation financing emissions control) were present in 2017-2019. They represent a starting point of focus on the management of the environmental impact. And from 2021 onward, researchers shifted their attention to energy efficiency and renewable energy sources (the two topics with the most occurrences), indicating much stronger and increasing interest. In addition to this shift in focus, the most recent years (2023-2025) suggest that researchers are starting to place more value on sustainable development, green economy/finance and developing countries as part of an overall strategy that incorporates both environmental objectives and economic growth and policy objectives.

Co-occurrence Network

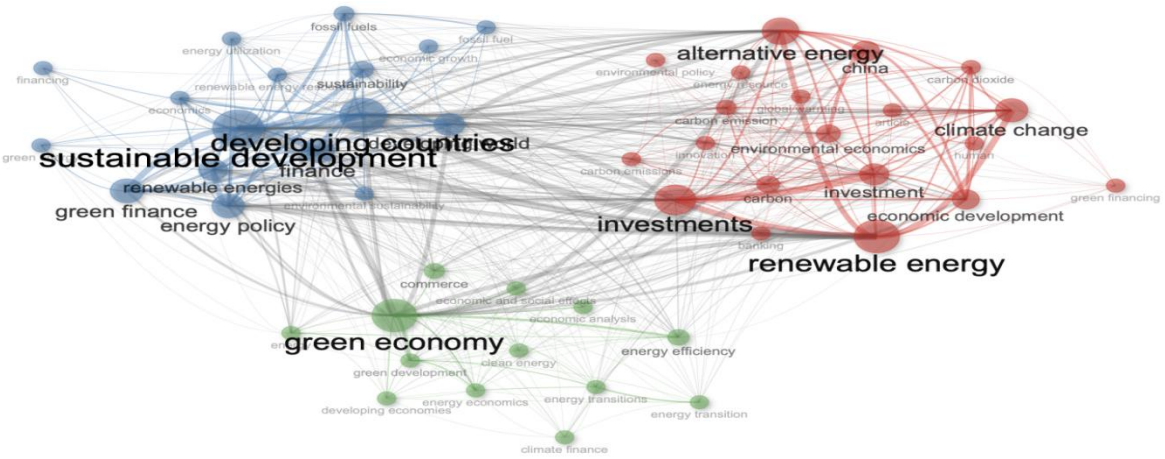

Figure 8. Co-occurrence Network

Three thematic clusters are revealed by the network maps. In the blue cluster, the focus is on sustainable development and developing countries, as well as policies, finance, and renewable energy. The red cluster is made up of investments in renewable/alternative energy and climate change, and a relationship between these two themes and economic development, as well as emissions. Finally, the green cluster encompasses the "green economy," which includes energy efficiency, transitions, and economic analysis. These clusters show that there are very dense connections between the three areas, indicating that sustainability, energy transition, and finance are all integrated and involve transdisciplinary research.

Thematic Map

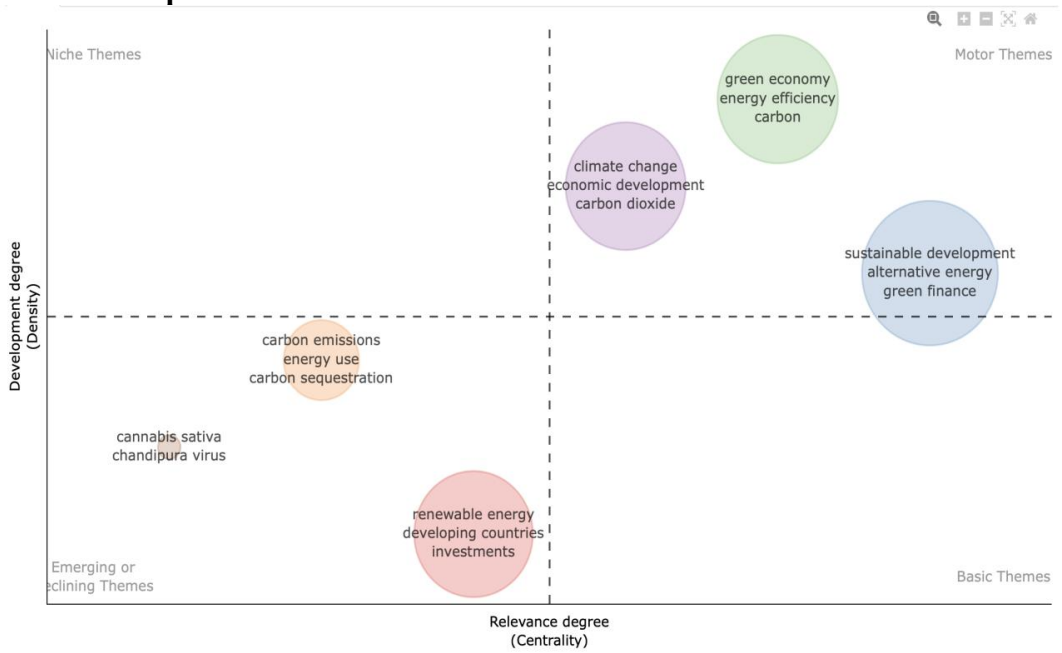

Figure 9. Thematic Map

The thematic map indicates that there are three main themes; sustainable development, alternative energy, and green finance which all have high relevance and moderate development. The other three themes, green economy, energy efficiency, and carbon, are well-developed 'motor' themes that contribute towards the industry as a whole. Climate change and economic development are considered central and moderately developed, serving as both connecting themes and large elements of sustainable development. The final three themes that are developing to be large will be renewable energy, developing countries, and investments; all of which have been found to be currently only moderately mature, yet are growing in importance. Others, such as carbon emissions, and energy use, are both considered to be in either a niche area or declining.

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Colaboration Network

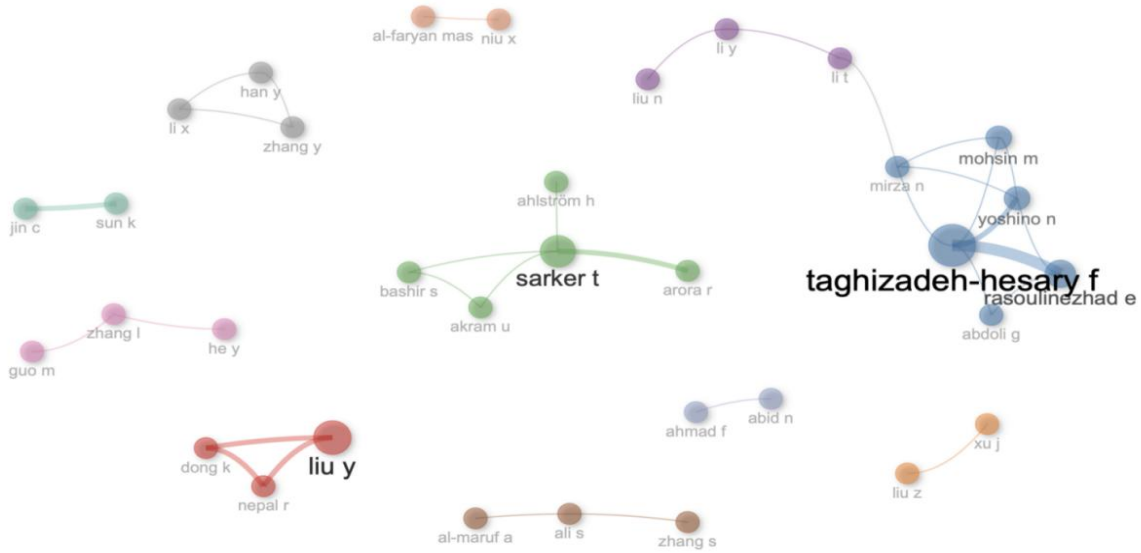

Figure 10. Collaboration Network

There are numerous small clusters in the collaboration network while a small number of authors are dominant. Five (5) authors form the basis of the study with Taghizadeh-Hesary F being the most central node, indicating that he is also the most strongly connected to other authors in terms of having influence on their collaborative efforts. Sarker T and Liu Y have comparatively large networks but not nearly as large as Taghizadeh-Hesary F's. The other authors have formed isolated and/or very small groups indicating a lack of cross-group collaboration between them. In sum, the field has some principal authors but they are not very well connected with one another as a whole.

Countries Collaboration World Map

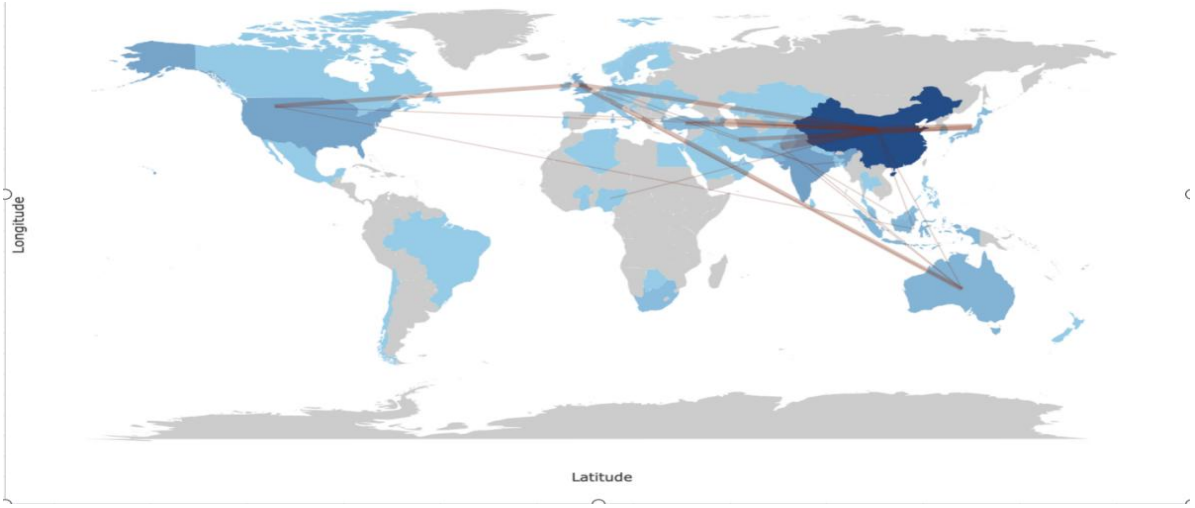

Figure 11. Countries Collaboration World Map

The map shows that there is an obvious global collaborative core-periphery structure, with China being the main centre and therefore having the most links globally. There are clear links between

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China and other nations such as the United States, Europe, and Australia as well as linkages between the United States and other Western European countries. There is also evidence of cooperative behaviour across the Asia-Pacific nations, with India in particular showing signs of strong regional collaboration; however, the majority of Africa and some parts of South America demonstrate low overall levels of linkage to these regions, indicating that they are less actively partaking in global research activities.

Clustering By Coupling

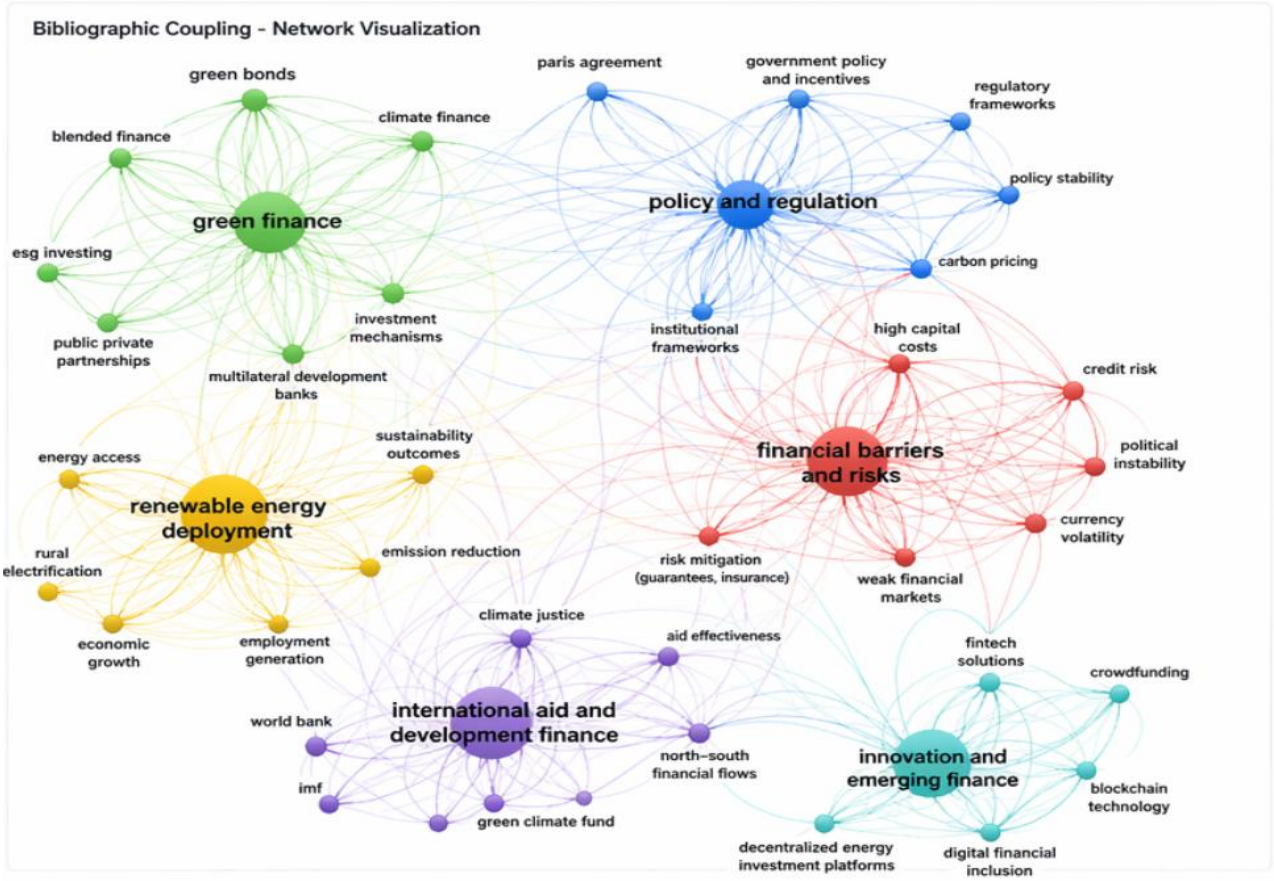

Figure 12. Clustering by Coupling

The network map illustrates the existence of six distinct thematic clusterings in financing green energy through the lens of existing literature. Within this graph, the green finance cluster represents the use of instruments such as green bonds and blended financing. Additionally, as the largest central theme connecting all six clusterings, policy and regulation are presented as central and highly connected. Similarly, the financial barriers and risks cluster demonstrates key constraints (e.g., high capital costs and political instability) that present significant challenges to implementation. The renewable energy deployment cluster shows how financing connects with outcomes, including energy access and economic growth; meanwhile, international aid and development financing demonstrate how reliance on multiple global institutions and funding flows exist within this structure. Finally, the innovation and emerging financial cluster (consisting of emerging technologies) emphasizes the increased interest in financial technology and alternative sources of financing. In summary, this map illustrates how interconnected the thematic structures are and how both policy and finance mechanisms will significantly affect the availability of green energy financing.

Discussion

In recent years, research has focused increasingly on green finance, particularly following 2020 as governments across the world made climate commitments; technological advances allowed new forms of financing; and governmental policies supported efforts to achieve net-zero emissions and sustainable development. There is still concentration in the research in terms of journals and authors, but there are a growing number of interdisciplinary studies being published. In addition to research concentration, the geographical distribution of research is heavily weighted towards China and India, while Africa has less research in part due to an unequal distribution of resources and capacity.

This research is fundamentally multidisciplinary and places a strong emphasis on how policy and regulatory frameworks shape the investment landscape. Although there are many instruments (e.g., green bonds and public-private partnerships) being used to increase private-sector participation, significant financial barriers (for instance, high upfront costs, long payback periods, and political/currency risk) continue to constrain private-sector investment in green energy. However, emerging technologies, including fintech and blockchain-based solutions, have the potential to improve access and efficiencies in green finance. Therefore, while there has been a great deal of progress in this area, there are still structural barriers to the scalability of green energy financing in developing economies.

Conclusion and Directions for Future Research

A literature review was carried out to determine the number of articles published regarding the evolution of green energy financing (GEF) research in developing nations. The bibliometric analysis was conducted to define the number of published papers (years 2000–22) of GEF research based on a bibliometric analysis of a total of 346 research publications related to GEF in developing countries.

Through analysis, it was discovered: the number of GEF research articles published annually has greatly increased over the past five years; global concern about climate change, sustainable development and renewable energy generation has fuelled this increase; GEF instruments, such as green bonds or blended financing, provide considerable leverage to finance renewable energy projects; an inability to finance GEF onto a large scale is primarily due to the existence of weak institutions, uncertainty of the policy environment, or risk to investors; research contributions are not

equal internationally; and that there is little or no collaboration between researchers in developing countries and developing countries.

To achieve successful green energy transitions (GETs), it is necessary to have not only innovative GEF financing tools, but also strong governance, stability of the political environment, and cooperative efforts between the global community and developing nations.

To develop an improved understanding of local problems, it will be important for future research to investigate region/country-specific studies; particularly in areas that are often overlooked. Future research will include assessing the real-world effectiveness of financial mechanisms; finding new ways, particularly in regards to Fintech and digital finance, that can be used to meet those needs; and comparing different policy frameworks to determine which are most effective. Additionally, more emphasis should be placed on risk mitigation; financing at the micro level for startups and SMEs; and inclusion of ESG factors; via the use of a longitudinal and mixed-methods research design, in order to provide greater insight into these issues.

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