

Financing Sustainable Development Through Green Bonds: Mapping Research Development Through Bibliometric Analysis

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Abstract

Climate change and unsustainable use of the natural resources has impacted the basic necessities of living being, like fresh water, food security and energy and habitation zone of animals. This has attracted the attention of entire globe and has pushed the academicians, researcher and entrepreneurs to focus on sustainable alternatives to mitigate this risk. Green Finance emerged as an initiative of economies and financial system innovation.

There are various sources of green finance, the present study emphasizes on how the Green Bond can be a viable source to finance sustainable development.

This paper is an effort to identify the current dynamics in the green bond and sustainable development and suggest further research areas that can be explored. We have used Bibliometrix 'R package' to examine the 219 research papers to analyse research trends.

Keywords

Green bonds; Green Finance; Sustainable Development, Green bonds; Bibliometric analysis

Introduction and Literature Review

Since the Industrial revolution it has been a rat race among the countries to develop themselves for better living standard and ease of living. This led to voracious use of natural resources as if it is going to last forever and at a very hefty cost of deteriorating our own environment and natural resources. This incessant act certainly not paving the way towards the development, led to the emergence of a new concept of sustainability. Climate change and global warming posing a great threat to our survival and required a collective contribution from the entire world. Paris agreement, 2015 turned out to be a milestone which brought the entire nation under one roof to collectively contribute towards reducing the Green House gases (GHg) and carbon footprint to tackle the climate issues.

In the 1992 "United Nations Earth Summit Rio de Janeiro", Sustainable development concept

emerged as one of the key concept and as the priority International policy (Chichilnisky,G., 1999). “In 1987,Brundtland commission defined sustainability as ‘meeting the needs of the present without compromising the ability of future generations to meet their own needs.’” (Brundtland,G.H., 1987).

The idea of green finance is different from the conventional financing like banking, conventional bonds and it helps to protect the environment by incorporating sustainable alternatives in the project it is being funded (Zhang et al., 2019). Green Bond is like regular bond but the key difference is that the proceeds raised from the investors are utilized to finance project which create positive impact on environment such as renewable energy, green buildings. According to a report issued by World Economic Forum (WEF) in 2023, Fostering Effective Energy Transition, \$270 billion was spent in 2020 through green bond issuance. United Nations Intergovernmental panel on climate change estimates that to restrict the temperature increase up to 1.5 degree Celsius, the goal set in ‘Paris Agreement’, it will require over \$3-6 trillion every year (WEF 2024).

Green bonds can be categorized into two types: “certified green bonds” and “self-labeled green bonds”. Certified green bonds have undergone a formal certification process to obtain a green label, while self-labeled green bonds are designated as green by the issuer themselves. (Shi et al., 2023).It is possible that company issuing green bond may not be using it for the green project but pretending to do so that is greenwashing as highlighted in the studies of (Xu et al, Baldi & Pandimiglio, 2022; Shi et al.,(2023).Greenwashing poses a significant inherent risk associated with the emerging category of corporate Green Bonds. The empirical study also demonstrates that greenwashing may be more perilous in manufacturing sector than in service sector Baldi & Pandimiglio, (2022). It has been considered that third party certification of Green Bonds prevent Greenwashing and incentives from government can provide issuers a reason to not greenwash Green bonds Zhu et al.,(2024).

The role of local government in quality development and sustainable urban management can be substantial Guan et al.,(2024).This study uses two-way fixed effect model to empirically analyse data collected from 30 provinces in China from 2010-2019.The study demonstrates that there is significant effect of local government debt on green development efficiency. Majority of the green bonds issuance comes from the private sector and scanty from the local government in the world Zamani, B & Dessi (2017).Financial situation of the local government is often not good, due to taxation system revenue does not percolate to local government as needed which makes it imperative for local government to seek an alternative source of funding Milewska,(2022).

The current paper focuses on the dynamics and main research areas of sustainable development through Green Bond as a means of finance and exploring Green Bond as a source of finance for the Local Government (Municipal government) and tries to address the following research questions:

Research Questions

RQ1: What is the publication and citation trend and which are the leading influential journals?

RQ2: Which academic publications are widely recognized as the most authentic?

RQ3: What are the most frequent keywords?

RQ4: Which authors and research institutions have made the important contributions?

RQ5: What is the present status of research collaboration?

RQ6: What is the intellectual structure of present literatures?

RQ7: Which areas of current literature require further research?

Bibliometric analysis process

We have adopted the “five research steps as defined by (Zupic & Čater, 2015)” as the procedure for bibliometric analysis. The five steps to study the ‘bibliometric analysis’ have been illustrated properly by the **Figure 1**.

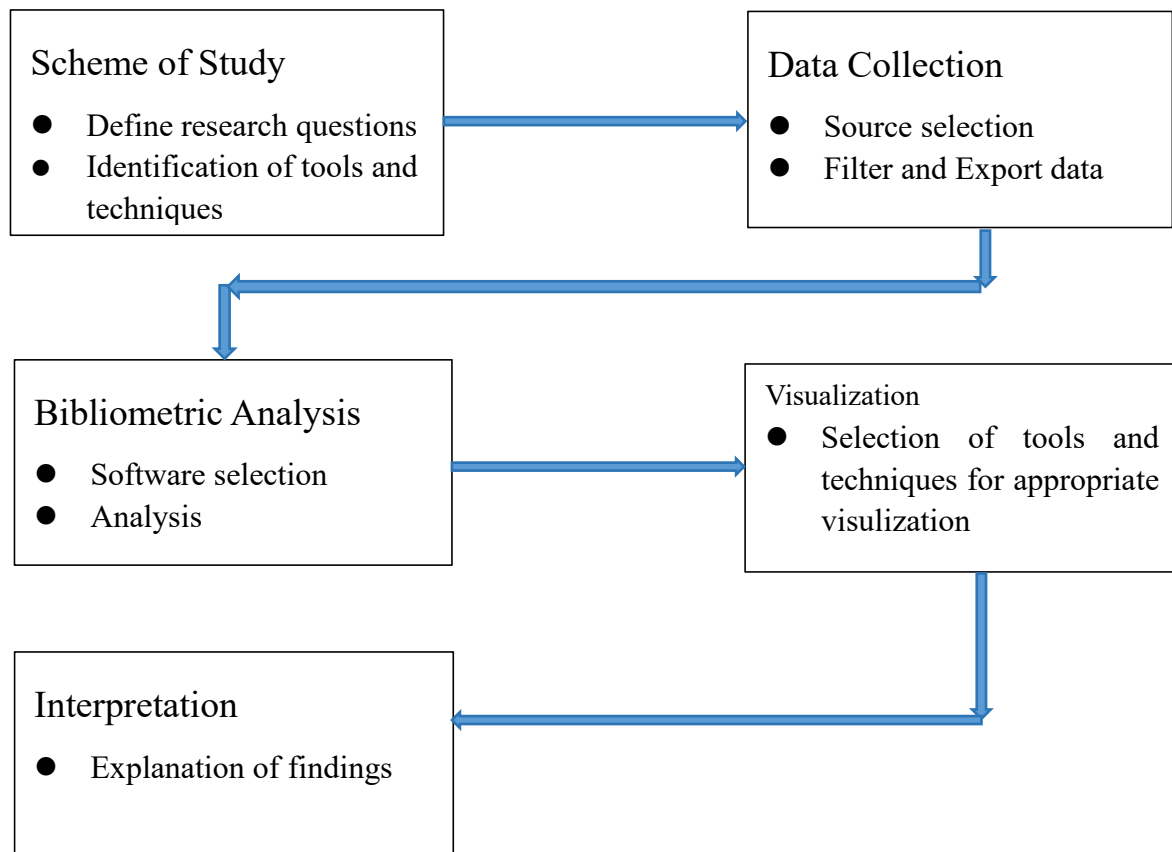


Fig. 1. Bibliometric analysis procedure

Scheme of study

Our use of various bibliometric techniques has led to significant findings that answer our research questions. These techniques include the use of descriptive statistics, the identification of core affiliations, publications, countries, authors, and sources of economic literature. We considered annual publications, total citations, and source impact for core

authors and core sources. Additionally, we used “Bradford’s law” to pinpoint key sources, a method that divides the sampled studies into three distinct zones. Zone 1, the ‘nuclear zone’, includes highly productive sources, while zone 2 includes moderately productive sources, and zone 3 consists of low production (Wardikar & Gudadhe, 2013). We have also used intellectual structure and social structure that uses co-citation network, collaboration network to find out collaboration among authors, countries and research papers that have been of importance and lastly we employed conceptual structure that includes co-occurrence network and thematic map to analyse how themes in this area have evolved and what are the prospects for research in this area. Our method allows us to recommend leading affiliations and countries based on overall citation counts and the frequency of publications.

Examining fundamental themes and central topics is important for connecting different research areas and pinpointing potential avenues for future research. For ‘bibliometric analysis’ we employed “Biblioshiny” tool from “R-Programme” to answer our research questions in the current literature.

Research Objective and analytical techniques

This study attempts to identify the trends in Green Bond as a source of finance for sustainable development and how the existing study have evolved during the study period. Also our objective is to identify future research directions. Our aim is to identify ‘core institutions’, ‘countries’, ‘authors’ and ‘research publications’ using “Biblioshiny” (“Bibliometrix 3.0”). In addition, our objective is also to recognize key research topics using science mapping methods, including ‘co-occurrence’ and ‘co-citation analysis’. By utilizing these research techniques, we can conduct a thorough analytical review and pinpoint gaps in the existing literature.

Selection of Dataset

We have used the ‘Scopus database’ to gather our data because it offers an extensive, and accurate results. We framed the boolean search string to find out literature in this domain and applied different filters to get optimum outcome. The search string used are as follows: ‘TITLE-ABS-KEY (“GREEN FINANCE” AND “GREEN BOND” AND “SUSTAINABLE DEVELOPMENT” AND (LIMIT-TO PUBSTAGE, “final”)). The final search outcome includes 345 articles. We limit our search query to find English language literature. Lastly, we analyzed manually to exclude articles and our sample size consists of 219 articles.

Bibliometric analysis and Visualization

We have used “Biblioshiny” under the Bibliometrics R package to perform bibliometrics analysis using the categories of intellectual structure, social structure and conceptual structure. Biblioshiny provides results through tables and graphs both for better visualization.

Table 1 provides descriptive statistics, which consists of useful information to understand before moving on with the rest of analysis. We have finalized 219 documents authored by

656 researchers out of which only 30 publications are single authored document which shows a higher degree of research collaboration.

Descriptive statistics

Description	Results
Main Information About Data	
Timespan	2017:2025
Sources (Journals, Books, etc)	107
Documents	219
Annual Growth Rate %	42.5
Average years from publication	2.21
Average citations per doc	31.29
References	12096
DOCUMENT CONTENTS	
Keywords Plus (ID)	1020
Author's Keywords (DE)	669
AUTHORS	
Authors	656
Authors of single-authored docs	28
AUTHORS COLLABORATION	
Single-authored docs	30
Co-Authors per Doc	3.2
International co-authorships %	36.99
Article	219

Table 1 Descriptive statistics

The annual publication and citation trends are shown in Figs.2 and 3, respectively. Annual publications trend can be divided into two phases, the first until 2020; where there is very limited contribution and then second phase from 2021 onwards where there is a very significant rise in the research contribution. Year 2025 shows decline since the data is for only 3 months. Annual citations trend shows a reverse trend where until 2019 the research papers citation are in increasing trend and the paper since 2020 onwards received less citations comparatively. This shows that visibility and influence of research contribution in later period decreased.

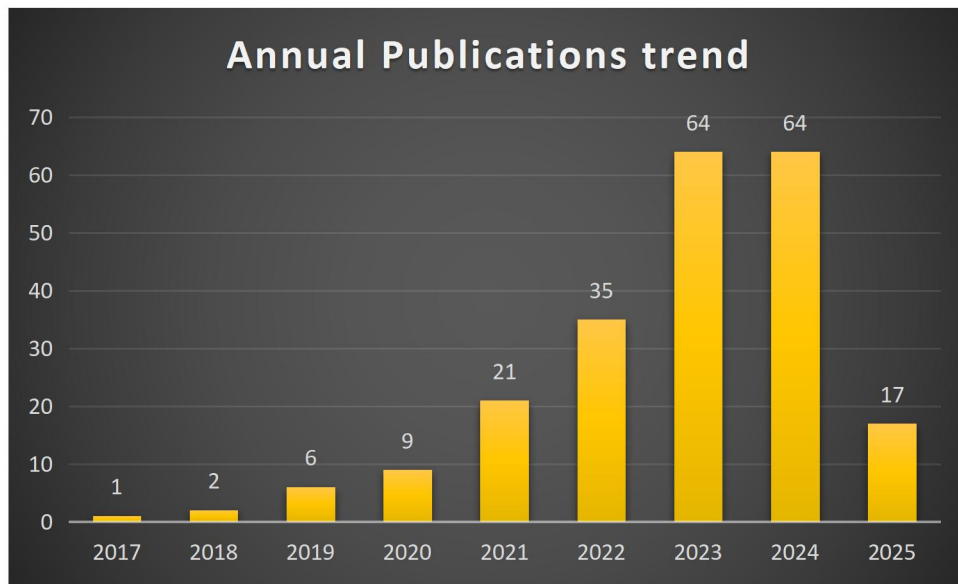


Fig. 2. Annual Publications trend

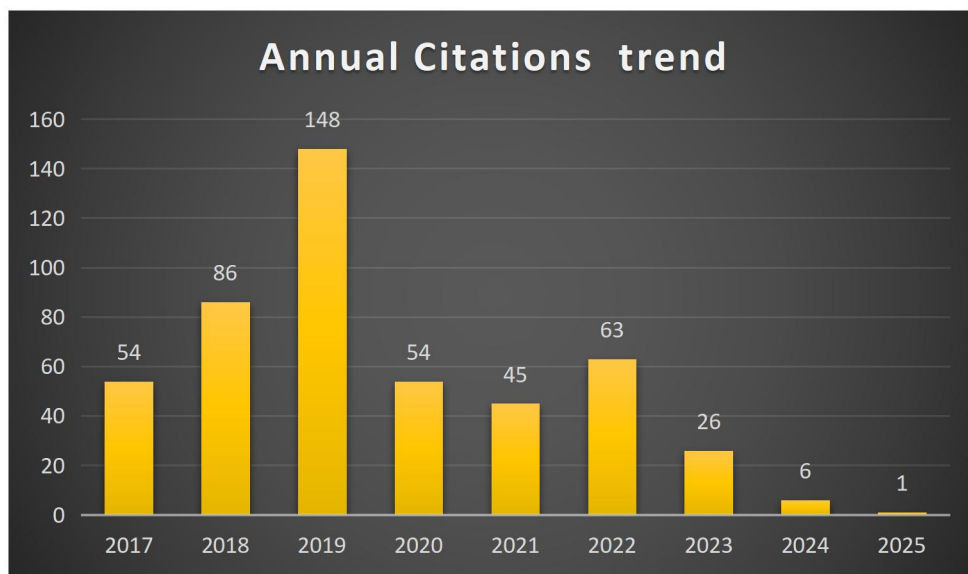


Fig. 3. Annual citations trend

To further explore, we have examined the main research themes, countries, and key journals. Fig.4 presents three-fold analysis of green bond and sustainable development using Three-field plot where the left side shows the key journals, key research themes in the middle and countries on the right side. The figure indicates that sustainable development, investments, green economy, green bond, finance and climate change are main research areas with majority of contributions coming from China, United Kingdom, India, Pakistan and Spain.

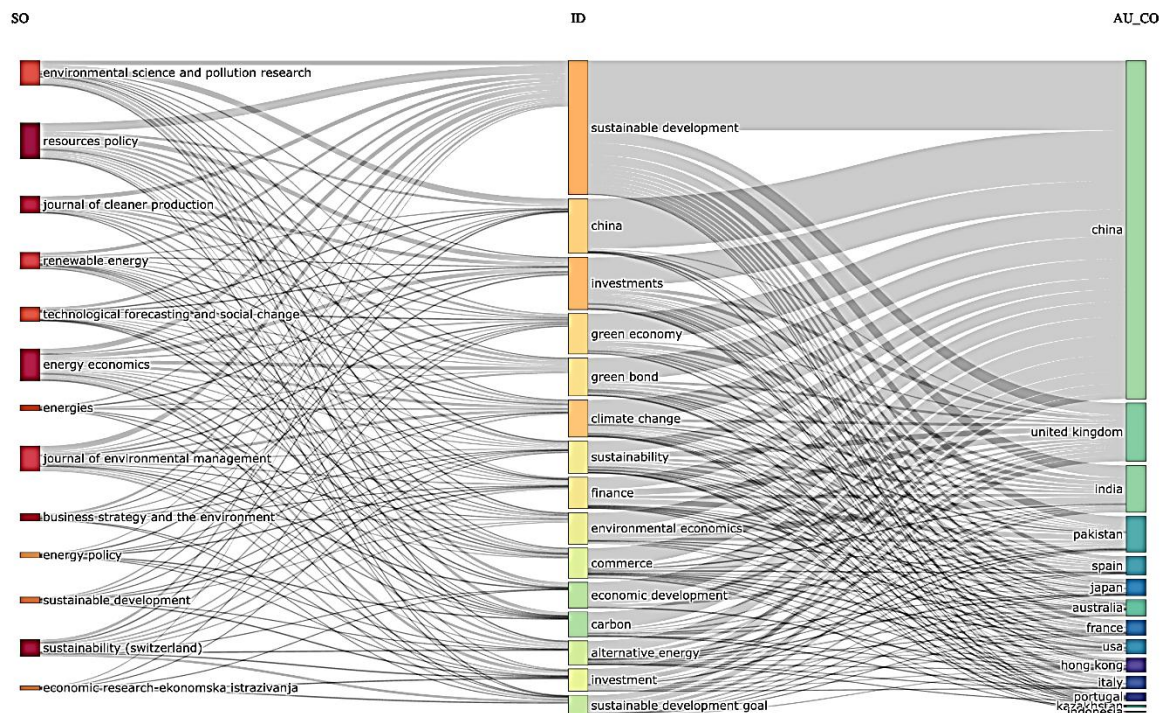


Fig. 4. Three Field analysis of research literature

Influential aspects of economic literature

Most influential research journals

We have used source impact and Bradford's law to analyze the effect of the most influential research journals. Table 2 lists the top 10 research journals based on total publications, publication starting year, total citations, and h-index. In comparison, Table 3 ranks the top 20 Research journals based on classification from Bradford's law, which classifies academic journals into three categories, with zone 1, including core research journals to publish literature related to sustainable development, investments, green bond, and climate change. It is also called the nuclear zone, which provides the most significant research contribution. From a total of 107 research journals, there are seven journals in Zone 1, 28 in Zone 2, and 72 in Zone 3.

Journal of Cleaner Production and *Resources Policy* are the most significant research journal as per the source impact and Bradford's law respectively. The key study featured in the journal was titled "Role of green finance in improving energy efficiency and renewable energy development" (Rasoulnezhad, 2022), who investigated how green bond are suitable method to promote green energy projects and reduce carbon emission significantly. The study employed regression on population, affluence and technology (STIRPAT) model to examine the relationship between CO₂ emissions, energy efficiency, green energy index (GEI) and green finance in the top ten economies supporting green finance. The result also showed no existence of any causal linkage between these variables in the short run which suggests that long term approach could help achieve sustainable economic growth for environmental

issues.

Source titles	h_index	g_index	TC	NP	PY_start
Journal of cleaner production	10	13	1194	13	2018
Sustainability (Switzerland)	9	13	331	13	2020
Energy Economics	8	13	401	13	2022
Resources Policy	8	16	502	16	2022
Business Strategy and the Environment	6	7	329	7	2019
Renewable Energy	6	7	272	7	2023
Journal of Environmental Management	5	7	433	7	2021
Technological Forecasting and Social Change	5	6	435	6	2021
Energies	4	4	65	4	2021
Environmental Science and Pollution Research	4	6	250	6	2021

Table 2 Top 10 Journals according to source impact

Sources	Ran k	Fre q	cumFre q	Zone
RESOURCES POLICY	1	16	16	Zone 1
ENERGY ECONOMICS	2	13	29	Zone 1
JOURNAL OF CLEANER PRODUCTION	3	13	42	Zone 1
SUSTAINABILITY (SWITZERLAND)	4	13	55	Zone 1
BUSINESS STRATEGY AND THE ENVIRONMENT	5	7	62	Zone 1
JOURNAL OF ENVIRONMENTAL MANAGEMENT	6	7	69	Zone 1
RENEWABLE ENERGY	7	7	76	Zone 1
ENVIRONMENTAL SCIENCE AND POLLUTION RESEARCH	8	6	82	Zone 2
TECHNOLOGICAL FORECASTING AND SOCIAL CHANGE	9	6	88	Zone 2
ENERGIES	10	4	92	Zone 2
HELIYON	11	4	96	Zone 2
JOURNAL OF SUSTAINABLE FINANCE AND	12	4	100	Zone

INVESTMENT				2
				Zone
SUSTAINABLE DEVELOPMENT	13	4	104	2
ECONOMIC RESEARCH-EKONOMSKA				Zone
ISTRAZIVANJA	14	3	107	2
				Zone
ENERGY POLICY	15	3	110	2
				Zone
FRONTIERS IN ENVIRONMENTAL SCIENCE	16	3	113	2
				Zone
COGENT ECONOMICS AND FINANCE	17	2	115	2
				Zone
ENERGY	18	2	117	2
				Zone
ENVIRONMENTAL RESEARCH LETTERS	19	2	119	2
				Zone
EURASIAN ECONOMIC REVIEW	20	2	121	2

Table 3 Journal rankings (Bradford's Law)

Gianfrate & Peri (2019) studied the convenience of issuing green bonds for European issuers. They used propensity score matching approach to study 121 European green bonds issued between 2013 and 2017. The result showed that green bonds are more financially convenient than non-green ones that is conventional bonds. Their findings support the view that these bonds can potentially play a major role in greening the economy without penalizing financially to the issuers.

Figure 5. demonstrates the publication trend in the top 7 scientific journals to understand research publication through time. Resource policy has made the most significant contribution to research. Sustainability (Switzerland) has made a substantial contribution since 2019 in a very short period.

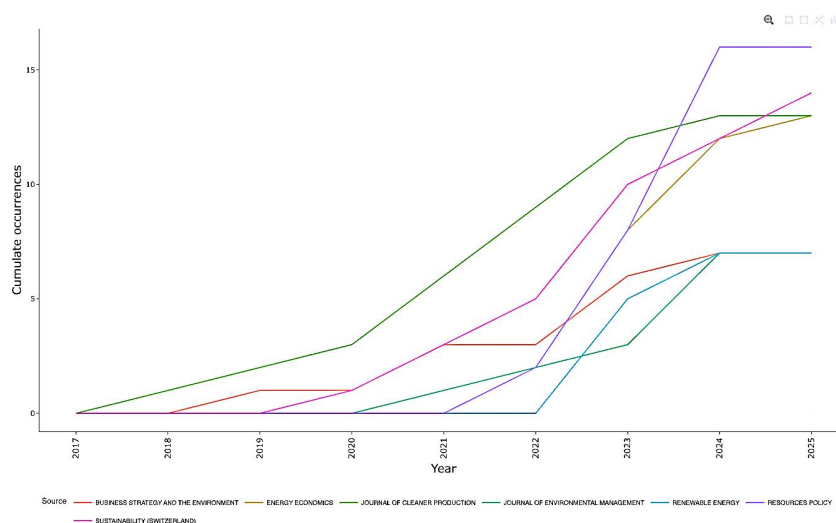


Fig. 5. Publication trend in top journals

Journal of cleaner production has made steady contribution since 2017 and Energy Economics also contributed significantly in very less time since 2023.

Core research Publications

The current section lists the top 10 green bonds and sustainable development literature research papers. **Table 4** presents global and local citations metrics, where global citations offer a comprehensive analysis while local citations focus on citation data from the selected literature. “The green advantage: Exploring the convenience of issuing green bonds” by Gianfrate, G (2019) stands out as the most frequently cited work where they studied the convenience of issuing green bonds for European issuers. They used propensity score matching approach to study 121 European green bonds issued between 2013 and 2017. “Do Investors in Green bond market pay a premium? Global evidence” by Nanayakkara & Colombage (2019) is the second most frequently cited work in which they studied the pricing difference of green bond and conventional bond in capital market worldwide. They used credit spread to observe investors preference and employed a hybrid panel regression model which makes it easier to capture the fixed effects of variables in a random effect model. The result shows that green label provides issuers an incentive to raise fund through issuing green bond and provides investors an opportunity to diversify their investments.

Paper Title	Corresponding author	Year	Local Citations	Global Citations
The green advantage: Exploring the convenience of issuing green bonds	Gianfrate, G	2019	42	344
Do investors in Green Bond market pay a premium? Global evidence	Nanayakkara,M	2019	12	143
The surge of impact borrowing: the magnitude and determinants of green bond supply and its heterogeneity across markets	Chiesa,M	2019	12	72
Green bonds, sustainable development and environmental policy in the European Union carbon market	Leitao,J	2021	9	63
Sustainable financing practices through green bonds: What affects the funding size?	Chiesa,M	2019	9	83
Exploring the determinants of green bond issuance: Going beyond the long-lasting debate on performance consequences	Russo,A	2021	7	76
Green bonds of supranational financial institutions: On the road to sustainable development	Versal,N	2022	4	35
From sustainability accounting to a green financing system: Institutional legitimacy and market heterogeneity in a global	NG.Artie	2018	4	161

financial centre

Financing for sustainability: Empirical analysis of green bond premium and issuer heterogeneity	Sheng,Q	2021	3	35
Dynamic connectedness among climate change index, green financial assets and renewable energy markets: Novel evidence from sustainable development perspective	Lorente,DB	2023	2	154

Table 4 Most locally and globally cited paper

Core words

The next crucial research question is to analyze the most frequent keywords in the literature. **Table 5** provides a statistical detail of keywords plus, authors' keywords, titles, and abstracts. Among all the categories in keyword analysis, Sustainable development, green bond, finance, and environment are the most common and prominent. Green, sustainable, bonds, and environmental have appeared for the maximum number of times in the 'titles and abstracts'. These words in the titles and abstracts, while common, have less probability to add on to the main research area, making research question all the more important.

The 'Word cloud', in the **figure 6** demonstrates keywords appearance, where a larger-sized cloud indicates that the word has appeared more often in the research article. Sustainable development, Investments, climate change, and green bond are the most frequent keywords. They not only strongly contribute to the literature but also hold the potential to inspire change, as the focus is to analyse how sustainable development can be achieved by financing through green bonds.

Keyword plus	Frequency	Titles	Frequency
Sustainable development	142	Green	199
Investments	86	Sustainable	72
Climate change	48	Bonds	100
China	46	Finance	80
Green economy	41	energy	45
Green bond	40	development	56
finance	36	Environmental	27
Authors Keywords	Frequency	Abstracts	Frequency
Green bond	134	Green	1147
Green finance	49	Bonds	747
Sustainable development	43	Sustainable	434
Renewable energy	28	Development	362

Sustainable finance	22	Energy	296
Environmental sustainability	11	Finance	281
Climate change	10	Environmental	248

Table 5 Most frequent keywords



Fig. 6. Publication trend in top journals

Prominent Researchers, research Institutions, and countries

The section provides information regarding most instrumental research contributions by researchers and research institutions and countries, and also states researchers' academic affiliations. Table 6 provides the top ten researchers ranked based on the publications. With the highest publications Farhad Taghizadeh- Hesary is the most influential author and focused on analyzing attributes of green bond markets that drive and enhance green financing initiatives. The study conducts a comparative analysis of the factors, risks, and returns of green bonds based on region. The research primarily concentrated on the Asia-Pacific region. It indicates that green bonds in Asia often exhibit higher returns, risks and variability .

Authors	Articles
TAGHIZADEH-HESARY F	6
ZHANG D	4
KUNG C-C	3
LIU Y	3
UMAIR M	3
ABAKAH EJA	2
AZAD S	2
BARUA S	2

BOUBAKER S	2
CHANG M-S	2

Table 6 Top 10 authors

Table 7 presents valuable statistical insights regarding the research contributions of the top ten countries. We have divided the information into two sections: the left side of the table lists countries based on research publications, while on the right side, we have ranked countries based on the most citations. China, India, the United Kingdom, Australia, and Japan consistently impact academic research as they appear on both lists.

Countries	Most publications	Countries	Most citations
China	199	China	1940
India	39	Japan	744
United Kingdom	32	United Kingdom	464
Ukraine	28	France	456
Australia	20	Australia	340
Kazakhstan	16	Austria	331
Pakistan	16	Pakistan	205
Spain	15	Oman	198
USA	14	Spain	170
Japan	13	India	154

Table 7 Top 10 Countries with highest number of publications and citations.

We enhance our research by exploring the influence of research institutions. ‘B. A School of Business and Finance’, Latvia, is ranked first with six academic publications, followed by ‘Shanghai University of Finance and Economics’ with six publications, and ‘Tokai University’, also with six publications, as shown in Figure 7.

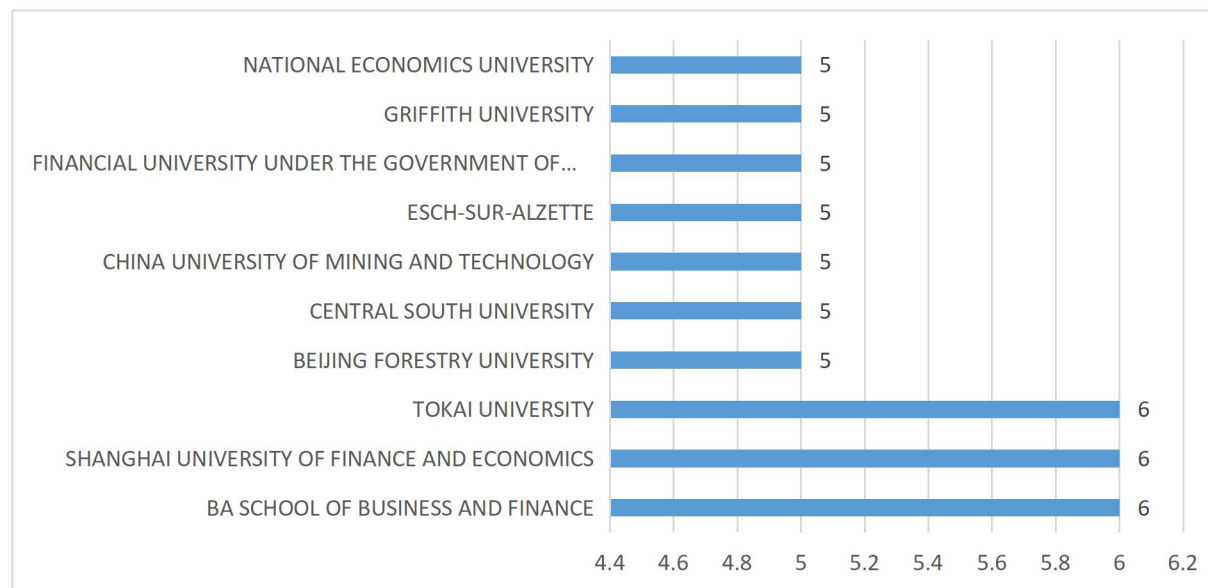


Fig. 7. Most relevant research institutions

Collaboration is key to unlocking new possibilities and effectively tackling the challenges we face in the academic field. Table 8 highlights the collaborative research efforts observed at the country level. China and Pakistan have undeniably emerged as frontrunners in collaborative research, showcasing their commitment by launching an impressive 9 joint projects. followed by China and Hong Kong, Japan, South Korea each 3 and U.K and Australia with 2 publications. China has emerged highest contributing countries and also this data shows that Asian countries are the most significant contributors and also highest in collaboration in this area.

From	To	Frequency
China	Pakistan	9
China	Hong Kong	3
China	Japan	3
China	South Korea	3
China	Lebanon	3
China	UK	2
UK	Australia	2
UK	France	2
France	Italy	2
Hong Kong	Singapore	2

Table 8 Collaboration among countries

Thematic analysis

One of the main aims of the present study is to unfold thematic foundation and trajectory of green finance research and suggest potential future study. For this we have used “conceptual network” which includes co-citation network, and bi-dimensional matrix “thematic maps”.

Thematic maps helps to pinpoint and record themes, patterns, and trends within a particular research area. Figure 8 showcases a thematic map created with Biblioshiny illustrating several significant themes. As per the results, we identified that environmental impact, clean energy, financial mechanism are the niche themes, while cleaner production, pollution control and market development are emerging themes. Additionally green economy, sustainable finance, green bond sustainable development are motor themes which indicates their central importance and influence within research landscape.

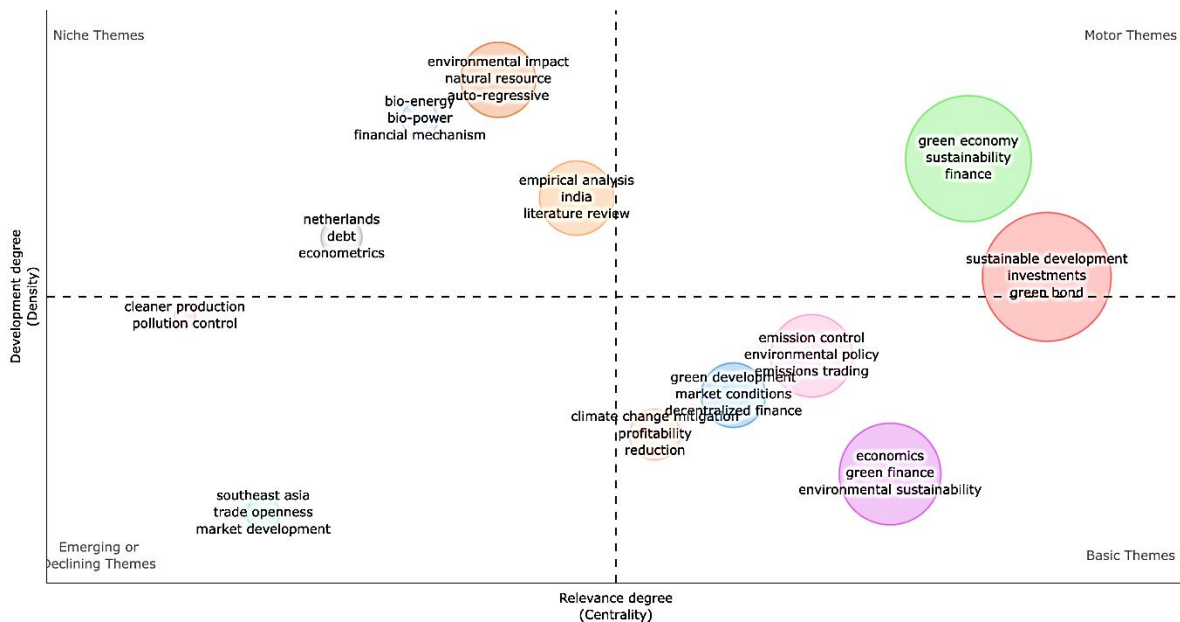


Fig. 8. Thematic map

Co-citation analysis

We begin our conceptual network analysis by analyzing co-citation analysis illustrated using **Fig. 8**. It is defined as “the number of time two articles are cited together”. This approach allows us to explore the intellectual structure, providing valuable insights into the latest developments in literature and the overall structure of research. (Rossetto et al. 2018). Our analysis identifies themes which are grouped in clusters and there are three such clusters-red, green and blue. The cluster with red color clearly highlights a unified research theme centered around green finance and its relationship to economic growth. In contrast, the green and blue clusters demonstrate broader thematic diversity and variability, showcasing the developing and specialized aspects of research in green finance.

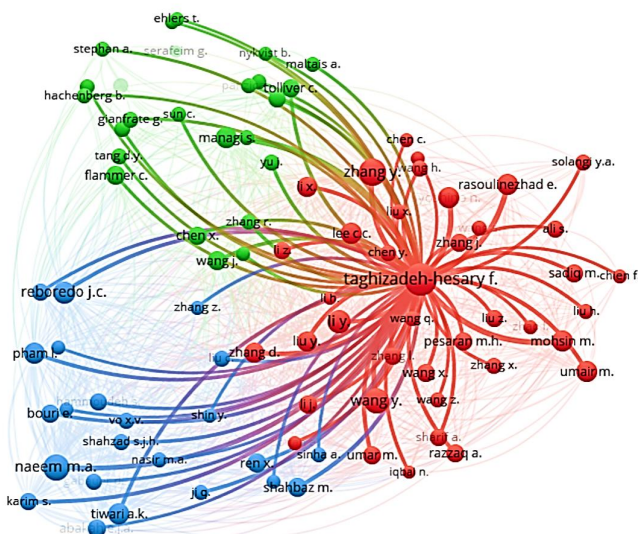


Fig. 9. Co-citation network

The co-citation network effectively organizes current research into three distinct clusters: red, blue, and green, highlighting diverse focus areas and promoting collaboration within the field.

Research questions and main findings

This section outlines the results of the research questions and offers recommendations for future studies to address the gaps present in the current literature.

The analysis of ‘descriptive statistics’ and publication trends illustrates how interest in ‘Green bonds’ and ‘Sustainable development’ has evolved over time (RQ1). It shows that there is significant increase in research contribution since 2021. “Resources Policy” and “Journal of cleaner production” has published most research literature as per the ‘Bradford’s law’ and source impact (RQ1), which has studied how green bond is used to finance the sustainable projects and how it impacts sustainable development. Our exploration reveals that the landscape of current research is largely molded by just a handful of influential studies (RQ2), where Gianfrate (2019) has most cited research publications titled “The green advantage: Exploring the convenience of issuing green bonds” followed by Nanayakkara (2019) “Do investors in Green Bond market pay a premium? Global evidence” and Chiesa (2019) “The surge of impact borrowing: the magnitude and determinants of green bond supply and its heterogeneity across markets”. Next, Keyword analysis demonstrates the major sub areas in which research investigations are happening most (RQ3), where ‘Sustainable Development’, ‘Green bond’, ‘Green finance’ and ‘Investments’ are the frequently repeated keywords. Taghizadeh has contributed to most research publication 6 and BA School of Business and Finance has contributed most (RQ4). The maximum research cooperation exists between China and Pakistan and China with 199 publications being the highest contributor in this field (RQ5). Co-citation and thematic map help us understand the conceptual structure and how research themes have evolved (RQ6). We have identified that over time, research into green bonds has evolved from technical and structural aspects to its usability and impact on economic activities like cleaner energy and sustainable infrastructure have been evolved. But still factors like under development of bond and green bond market structural barriers have led to under utilization of green bond as a means to finance sustainable and environment friendly projects (RQ7).

Conclusion

This study aims to enhance the insights of academic literature concerning the usability of ‘green bonds’ as a source to finance sustainable development. We offer valuable insights through bibliometric analysis of scientific publication spanning from 2017-2025. The findings indicate that green bond concept emerged in the research community around the beginning of twenty-first century being first green bond issued in 2007 by “European Investment Bank” known as “climate awareness bond”. Growth in the number of publications have increased significantly since 2007. ‘China’ is at forefront of green bonds and green finance studies

independently as well as in collaboration. But still the use of green bonds is at nascent stage. The impact of climate change on the environment requires that financing needs be addressed with more environmentally sustainable projects.

Limitation of the study and future research prospects

After a comprehensive bibliometric analysis, we conclude that several factors obstruct current research, and future studies can address these limitations. The scope and extent of this study were limited to the elements and methodology used. First limitation is that we only collected data from the Scopus database and excluded the other important database like Web of Science, because of lack of access, which may inadvertently omit some important studies. We assume that including additional databases will increase the robustness of the study. As Climate change, environmental issue and sustainability problem is a global issue there is a dire need that there should be a robust framework regarding green financing and green bonds which can be used by entire world. Also it is important to integrate research at global institutional level.

Growth in the number of publications have increased significantly since 2007. China is at forefront of green bonds and green finance studies independently as well as in collaboration. But still the use of green bonds is at nascent stage. The impact of climate change on the environment requires that financing needs be addressed with more environmentally sustainable projects.

Currently use of green bonds at local government level is very low and there is few research that have been conducted in this area so this is one important area to be explored which can bring great impact on sustainable economy and sustainable development.

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