Delhi Business Review Vol. 25, No. 1 (January - June 2024)

DELHI BUSINESS REVIEW

An International Journal of SHTR

Journal Homepage: https://www.delhibusinessreview.org/Index.htm
https://www.journalpressindia.com/delhi-business-review

Decoding Green Finance: Exploring Concepts, Themes, and Transformative Journey

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ARTICLE INFO

Article history:
Received - 23 December 2023
Revised - 19 February 2024
24 February 2024
Accepted - 12 April 2024

Keywords:
Environmental, Social, and Governance (ESG),
Green Finance (GF),
Sustainable Finance (SF),
Intellectual Structure,
Thematic Evolution, and
Biblioshiny.

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ABSTRACT

Purpose: The purpose of this study is to delve into the dynamics of green dn sustainable finance (GSF), focusing on its intellectual structure, conceptual framework, and thematic evolution. The research aims to explore how modern finance theories integrate Environmental, Social and Governance (ESG) principles to drive future ecologically responsible investments.

Design/Methodology/Approach: This research employees thematic mapping, co-citation relationships, and keywords analysis to conduct a comprehensive examination of GSF. These methodologies are utilized to distill essential concepts and identify primary themes that shape the GSF landscape. By involving experts from economics, environmental studies, and law, the study provides a multifaceted view of GSF.

Findings: The study identifies three main narratives in GSF: (i) the seamless integration of ESG values, (ii) the increasing prominence of environmental finance, and (iii) the role of broad policies in guiding ecologically conscious finance. The findings indicate that ESG principles are crucial for future investments and highlight the importance of cross-disciplinary collaboration in understanding GSF.

Research Limitations: While the study offers a thorough analysis of GSF, certain areas could benefit from further academic exploration to provide a more comprehensive understanding of the field.

Managerial Application: The research underscores the importance of integrating ESG values into financial decision-making processes. Managers and policy makers can leverage these insights to develop strategies that align financial objectives with environmental sustainability, thereby enhancing long term investment performance and social impact.

Originality/Value: This study is novel in its holistic approach to GSF, combining financial goals with environmental care. It documents the rise of GSF and provides a unique perspective on its critical role on shaping sustainable finance practices. The research offers valuable insights for academics, practitioners and policymakers interested in the intersection of finance and sustainability.

DOI: 10.51768/dbr.v25i1.251202405

Introduction

Lots of people are interested in Green Finance (GF) recently, which refers to funding ecologically friendly activities (Debrah et al., 2022; Fanea-Ivanovici & Siemionek-Ruskañ, 2023; Hooda & Yadav, 2023; Y. Huang et al., 2022; Jiang et al., 2020). The reduction of carbon emissions, the improvement of energy efficiency, and the protection of endangered species are all examples of environmental initiatives that might benefit from financial support. Green initiatives may reduce emissions of greenhouse gases and speed up the achievement of the SDGs. Uneven and imprecise effect estimate is a big problem when it comes to supporting green projects. To combat this, new eco-friendly financing options including green bonds and loans have emerged. These investment instruments aid in the open and public evaluation of project environmental benefits and financial allocation.

A subcategory of corporate bonds known as "green bonds" are issued to fund environmental projects (Agarwal & Singh, 2018; Cheong & Choi, 2020). The "International Capital Market Association" (ICMA) developed the Green Bond Principles to give issuers of green bonds a framework for voluntarily disclosing information and reporting on the bonds' performance. The regulations address a wide range of subjects, including the use of money, project appraisal, selection, reporting, and transparency (Nanayakkara & Colombage, 2022). Green loans are used to finance green activities in a manner similar to conventional loans. Green bonds are not publicly traded; instead, green loans are made privately between two parties. In accordance with guidelines established by the "Loan Market Association" (LMA) and the "Asia-Pacific Loan Market Association" (APLMA), green loans are structured similarly to green bonds.

(Debrah and others, 2022). GF is much more than just conventional financial products like bonds and loans. Included are structured products and financial structures that combine funds for environmental projects. These funds may be tailored to target particular industries, such renewable energy, or regions based on the investor's preferences. Governments play an equally significant role in the mobilization of green money as do institutional investors. Regulations may be established by governments to promote green investment. New disclosure and reporting requirements aim to educate the public about the environmental effects of the financial industry.

If you care about protecting the environment, studying GF is a must. The increasing need for sustainable development finance solutions has piqued the interest of scholars, decision-makers, and investors in GF. You may learn a lot about where GF and sustainable development research are at the moment and where they're headed by doing bibliometric analysis, which is reading through published publications to find trends and patterns. The fight for a sustainable future relies on GF in conjunction with sustainable development. Allocating investment funds to environmentally sustainable initiatives is one way GF may help achieve this balance. Social advancement, environmental preservation, and material prosperity all need to be balanced for sustainable development to be successful. GF has excellent chances to promote economic growth while preserving the environment. It includes investment instruments such as funds, bonds, and loans. Given that its origin is internal, the growth of it may be seen as organic. The growing awareness among the general public regarding the dangers associated with climate change and environmental deterioration has led to a remarkable surge in the popularity of GF (green finance) and sustainable development. The surge in research on the subject may be attributed to the 2015 Paris Climate Agreement, which mandates the development of strategies to accelerate the transition towards a low-carbon economy. The bibliometric study can provide an assessment of the current state of res-earch, the extent to which studies have addressed issues related to GF and sustainable development, and identify areas that require more attention.

This bibliometric study seeks to evaluate the present level of knowledge, identify emerging difficulties, and address knowledge gaps related to GF and sustainable development. This analysis aims to provide insight into the historical and present condition of research in this subject through the use of citation analysis metrics, specialized tools, and database searches. These methods will be employed to identify the papers, authors, and themes that have had the most impact. This bibliometric study can provide researchers,

practitioners, and legislators with a more comprehensive understanding of GF and sustainable development, so benefiting their work and decision-making. In addition, they could point us in the direction of the places where our knowledge is most inadequate, so we might focus our inquiry there. With this in mind, the following individuals are selected to participate in the study:

1. Who among the following has had the greatest influence on the development of green and sustainable finance (GSF)? Publications, writers, groups, governments, and associations?
2. How has the GSF research progressed thematically and conceptually?
3. How does the current framework of GSF research stand conceptually?
4. What areas of the GSF still require more study?

Research Methodology

According to Machado et al. (2014) and Petersen et al. (2015), a systematic literature review is an extensive process that involves gathering, assessing, and interpreting the most current articles on a certain subject or area of study. Finding, collecting, and synthesising pertinent content from a variety of reliable sources, including books, academic journals, and conference papers, are the main goals. Speci- fically, we use a three-stage iterative cycle approach in this study, beginning with keyword selection and ending with analysis, to search the selected database for relevant literature. The method's high-level outline is shown in Figure 1.

Creating a Search Query and Gathering Information

We began by doing keyword searches that combined Sustainable Finance (SF) and Green Finance (GF) to ensure a comprehensive coverage of the subject. The study's data was gathered both manually and automatically from the Scopus database, which contains an abundance of research on GF and sustainability. More journals are included by Scopus, a more extensive database than Web of Science (WoS), but its biases are comparable to those of WoS (Bakhmat et al., 2022; Singh et al., 2021). Consequently, the aforementioned "title, abstract, and keywords" criteria were used to conduct a Scopus search in an effort to remove any potential biases the search query was used on the basis of previous research done in this field (Akomea-Frimpong et al., 2022; Fanea-Ivanovici & Siemionek-Ruskañ, 2023; Naeem et al., 2022; Yu et al., 2021; D. Zhang et al., 2019). Searching by title, abstract, and keywords using Boolean logic "OR" and "AND" yielded 1775 results for online papers published as of June 2023.

Refinement of Data

In order to fulfill the need for the software, data from the Scopus database were obtained and saved in CSV format. On June 23, 2023, papers were selected for shortlisting based on the search parameters that are detailed in the following paragraphs. In the vast majority of research proposals, both the phrases GF and SF are utilized. As a consequence of this, the scientific material that was pertinent to GSFwas located through the utilization of the keyword search criteria, and a total of 1775 papers were retrieved through the utilization of a keyword search in either the title, the abstract, or the keyword list. The following is an explanation of the search approach that was applied to this research project:

All papers published on the topic of GSF between the years 2000 and 2023 were compiled into a database. At this point 1769 articles have been culled. Several factors led to the selection of the year 2000 and beyond. First, SF and investment have recently received a great deal more attention and focus (D. Zhang et al., 2019). It is feasible to identify trends in the development and growth of this emerging

(TITLE-ABS-KEY (green AND finance) OR TITLE-ABS-KEY (green AND financing) OR TITLE-ABS-KEY (green AND credit) OR TITLE-ABS-KEY (green AND investment) OR TITLE-ABS-KEY (green AND securities) OR TITLE-ABS-KEY (green AND bond) AND TITLE-ABS-KEY (sustainable AND financing) OR TITLE-ABS-KEY (sustainable AND finance) AND PUBYEAR > 1999 AND PUBYEAR < 2024 AND (LIMIT-TO (DOCTYPE , "ar") OR LIMIT-TO (DOCTYPE , "cp") OR LIMIT-TO (DOCTYPE , "ch") AND LIMIT-TO (LANGUAGE, "English"))

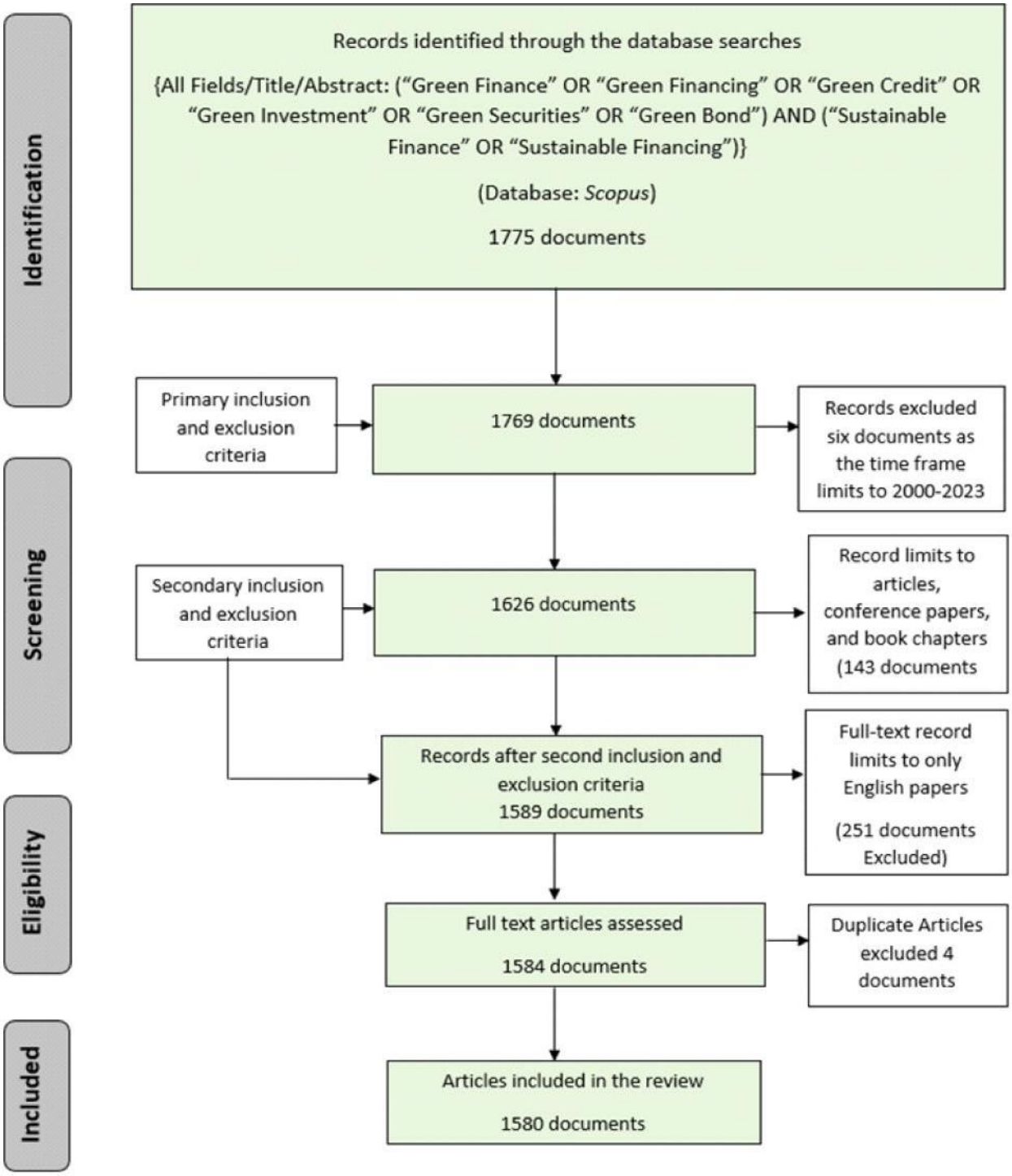


Figure 1: PRISMA Model

Source: *Computed by author*

subject of finance by thoroughly examining information from the year 2000. Furthermore, the implementation of updated guidelines for ESG (Environmental, Social, and Governance) factors, which have been made mandatory for businesses (Atz et al., 2023; Macchiavello & Siri, 2022; Ziolo et al., 2019), has simplified the process of obtaining and evaluating data

related to environmentally friendly and sustainable financial activities. Overall, Hooda and Yadav (2023), Tolliver et al. (2019), and X. Zhang et al. (2018) emphasize the significance of sustainable funding and investment in light of recent legislative progress, such as the implementation of the Paris Climate Agreement in 2015. An analysis of the impact of these changes in legislation on current financial and investment practices may be initiated from the year 2000 forward. Technological advancements have led to the emergence of new financial systems and products that encourage sustainable financing (Hailiang et al., 2023; H. Liu et al., 2022; Tong et al., 2022). By utilizing data spanning from 2000 on-wards, the researchers can analyze the impact of these alterations on the expansion of SF. Looking at the GSF data set from 2000 onwards could help you spot the big trends, problems, and opportunities that have influenced SF and investment so far and will influence them going forward. In addition, we limited the document type to articles, conference proceedings, and book chapters, and we only included research that was initially published in English, all for the sake of clarity. Titles, authors, abstracts, and keywords were among the pieces of information about these papers that were sent to Biblioshiny in CSV format. The Bibliometric database was updated with 1580 new documents after data was cleaned up to remove duplicates and ensure all file types were supported.

Results And Interpretation

A. Descriptive Analysis

In this study, we provide a comprehensive review detailing the prevailing patterns in scholarly contributions, highlighting significant publications, dominant journals, esteemed authors, leading institutions, and countries in the realm of GSF. This exploration aims to address *RQ1* (Which publications, authors, sources, organizations, and nations have had the most impact on the study of GSF?).

Sample characteristics

An overview of the bibliometric data frame for the 1580 publications chosen by a systematic search query in the Scopus database is provided in Table 1, together with descriptive analysis and discussion of the various study-relevant characteristics. These articles, which were published in 630 different sources, show considerable preceding research with author collaboration with an average citation score of 13.29 and a global co-authorship rate of 27.97%. In addition, the average number of contributors listed in the authors' index of a given manuscript is greater than two (3.08).

Annual scientific production

Figure 2's output patterns from 2000 to 2023 show that just 47 articles, or 2.97% of the total production, were published between 2000 and 2010. Likewise, 1,533 articles, or 97.02% of the total, were published in the ten-year period from 2011 to 2023. The first five months of 2023 saw the creation of 371 articles. According to the figure, the manufacturing trend for sustainable financing is rising dramatically. Furthermore, it is noted that until the early 2000s, which marks the start of the study and relatively few articles are reported, the first few years were not particularly focused on GF. The legislative measures, investor demand for sustainable investments, participation of financial institutions, academic and institutional focus, and increased awareness of climate change all contribute to the growth of the field of GSF research.

Three field plot

A three-field plot chart of the 10 most illustrious authors, top sources, and most important keywords is shown in Figure 1. The relationship between authors (left), sources (right), and keywords (centre) is depicted in the picture using Sankey Plots. The size of the component is proportional to the node's value in the figure, which gives an overview of the contributions of various authors from various Sources and with various keywords. The terms "GF," "sustainable development," "renewable energy," "green innovation," "green bonds," and "climate change" were among them in the dictionary of terms. According to the analysis, the key writers on "GF," "sustainable development," "renewable energy," "green innovation," and "climate change" are Liu Y, Li Y, Taghizadeh-Hesari F, and Sun Y. Furthermore, the recommended journal for

Table 1: Data Characteristics

Description	Results
Main Information About Data	
Timespan	2000:2023
Sources (Journals, Books, etc)	630
Documents	1580
Annual Growth Rate %	25.49
Document Average Age	2.86
Average citations per doc	13.29
References	71235
Document Contents	
Keywords Plus (ID)	4596
Author's Keywords (DE)	3937
Authors	
Authors	3630
Authors of single-authored docs	273
Authors Collaboration	
Single-authored docs	292
Co-Authors per Doc	3.08
International co-authorships %	27.97
Document Types	
article	1198
book chapter	155
conference paper	227

Source: *Computed by author*

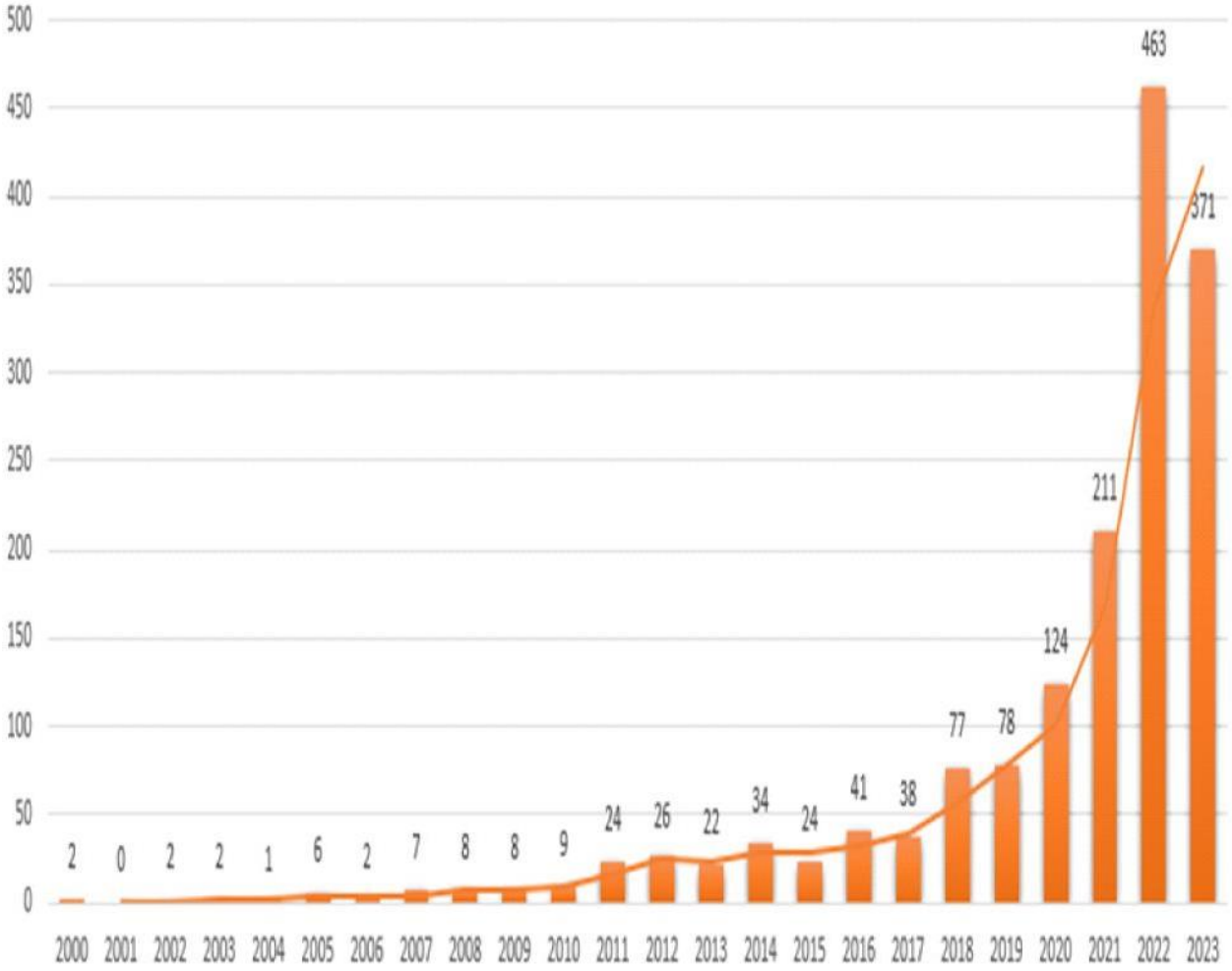
GSF is still "Sustainability," "renewable energy," and "frontiers in environmental science."

Most relevant sources

The top 20 sources that are most pertinent are shown in Table 2. *"Journal of Cleaner Production"* has the most citations and the most articles (48 articles and 2373 total), followed by *"Sustainability"* with 31 articles and 1154 totals. It's noteworthy to notice that this journal, which began publication in 2009 and currently maintains the second rank, has a reasonably high h index and has garnered numerous high-quality citations. This clearly shows the high caliber of production. With 24 articles published and 1027 citations, *"Journal of Environmental Management"* also receives high marks from the h index. *"Environmental Science and* Pollution Research" comes next, with 30 publications and 966 citations.

Most relevant authors and affiliations

From 2000 to 2023, 3630 writers from 1515 associations and 94 nations have written works on GSF. The total number of publications and citations was used to determine which writers in the study field were the most pertinent. While the overall number of papers reveals the writers' output, the total number of citations reveals their impact on the res-each community. The most productive writers



RQ1: Which publications, authors, sources, organizations, and nations have had the most impact on the study of green and sustainable finance?

Figure 2: Annual Scientific production and publication growth in the field of green and sustainable finance

Source: *Computed by author*

are Wang Y, Taghizadeh-Hesary F, Liu Y, Li Y, Li X, and Zang Y (Left panel of Table 3). Though it's crucial to recognize that this area of study is a worldwide endeavour, it's also clear from the table that China has emerged as a significant participant in GSF research (Right panel of Table 3). Chinese environmental issues and regulations (Feng et al., 2020; Y. Liu et al., 2020; Wu et al., 2020), the size of the Chinese economy, Chinese government financing and support to research, international agreements like the Paris Agreement (Tolliver et al., 2019; Zahan & Chuanmin, 2021), and promotion of the Belt and Road projects (Harlan, 2020; Malik et al., 2021; Reed & Trubetskoy, 2019) may all be major contributors to China's substantial position in the field of sustainable and GF. The above-mentioned reasons are also responsible for china's top position followed by USA, India, Malaysia and UK in terms of total article published and this same set of reasons again puts china on the top followed by Japan, UK, USA, Pakistan and Australia in terms of citations (Table 4).

GF papers typically receive a lot of citations. The article with the most citations (D. Zhang et al., 2021) has 328. The twenty publications

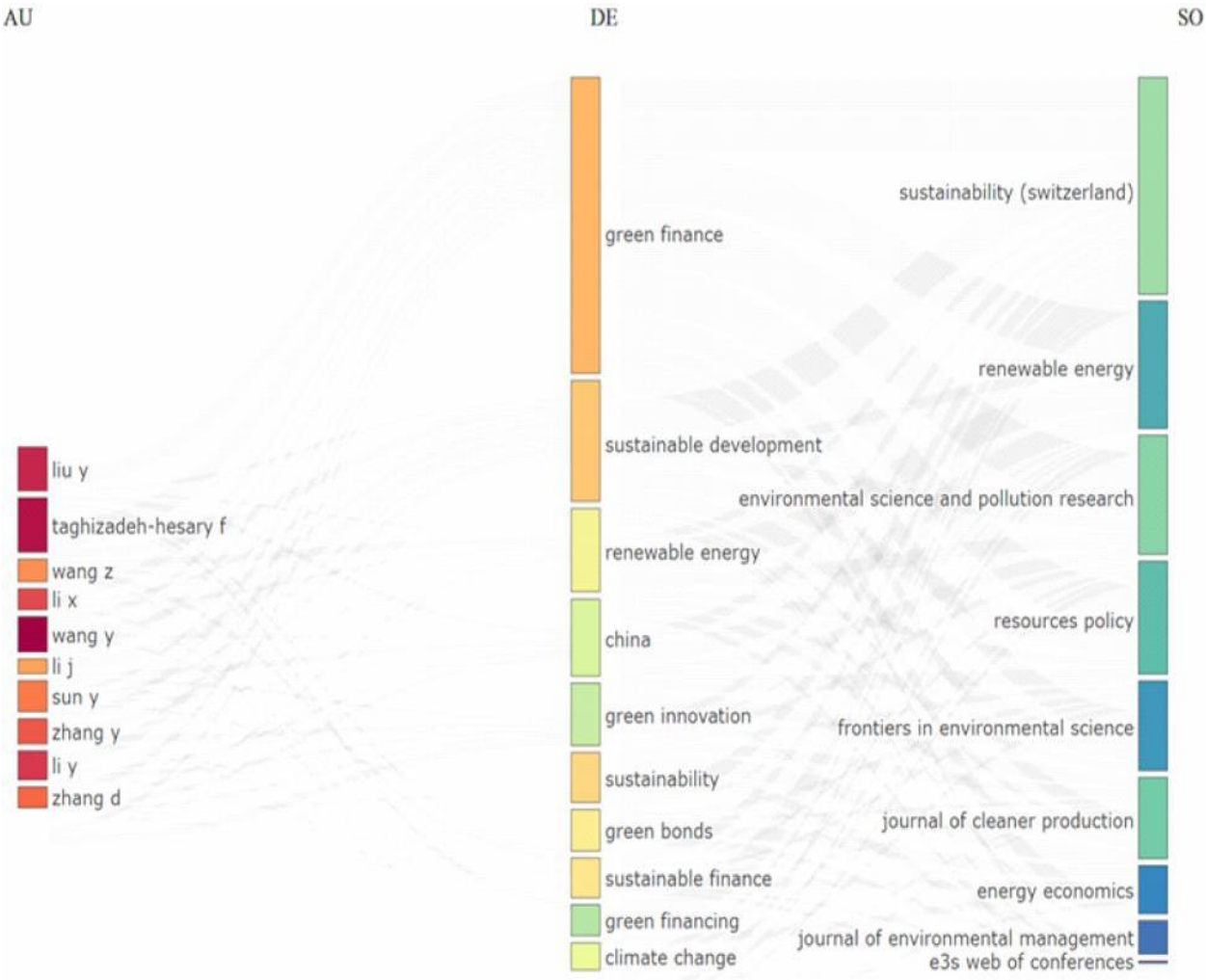


Figure 3: Three field plot: Authors (left), Keywords (middle) and sources (right)

Source: *Computed by author*

in our sample with the greatest citations are listed in Table 5. These 10 publications are drawn from a very diverse range of sources, demonstrating once more how multidisciplinary this topic is. We also look at where these articles got their references from.The plot is shown in Table 5. It is obvious that science, climate change, and environmental periodicals predominate. Although a few economics journals, such Ecological Economics and the International Journal of Production Economics, are demonstrated to have an impact on these studies, it is clear that finance journals, like Finance Research Letters, have nothing to do with them. The development of the pertinent literature network is also shown by the results of citation analysis for cited journals. It also makes it obvious that methods and models must be added to mainstream finance research in order to address GSF concerns.

Author's production

Delving into the landscape of GSF, our research unveils the influential voices and scholarly contributions. Table 6 curates an array of authors based on their citations, serving as an anchor for burgeoning collaborations. A standout study by (D. Zhang et al., 2021) observed inconsistent trajectories in green economic progress, highlighting potential governmental disparities. Their findings accentuated the ripple effects of strategic

Table 2: Most relevant sources by total citations

Element	h_index	g_index	m_index	TC
Journal of Cleaner Production	25	48	1.923	2373
Sustainability (Switzerland)	19	31	1.727	1154
Journal of Environmental Management	13	24	0.765	1027
Environmental Science and Pollution Research	17	30	3.4	966
Energy Policy	7	8	0.35	625
Resources Policy	13	24	2.167	620
Technological Forecasting and Social Change	11	16	1.375	580
Business Strategy and The Environment	10	14	0.476	510
Journal of Sustainable Finance and Investment	12	20	1	463
Finance Research Letters	4	5	0.8	422
Energy Economics	12	20	2.4	403
Ecological Economics	4	4	0.5	390
Renewable Energy	11	18	5.5	386
International Journal of Production Economics	4	4	0.4	358
Economic Analysis and Policy	10	17	3.333	319
International Journal of Environmental Research and Public Health	9	16	1.5	307
Energies	7	17	1.75	298
Science of the Total Environment	4	5	1	246
Journal of Financial Economics	1	1	0.333	246
Climate Policy	8	14	0.471	225

Source: *Computed by author*

investments in education and pioneering green technologies, shedding light on the nuanced benefits across nations. Further, they proposed tangible, theory-backed frameworks to galvanize the private sector's foray into green investments.Contributions from (Taghizadeh-Hesary & Yoshino, 2019; D. Zhang et al., 2021) enriched this narrative by furnishing actionable solutions to navigate the complexities of renewable energy financing. Creating community-driven trust funds, green credit assurance systems, and creative de-risking techniques were a few of them. The discussion also advocated for public financial actors and alternative financial platforms to have a bigger role in supporting long-term environmental commitments. The story was enhanced by data-supported affirmations by (Rasoulinezhad & Taghizadeh-Hesary, 2022), which demonstrated the transformative potential of GF on CO2 mitigation and economic propulsion. They echoed UNEP's comprehensive vision of a green economy by advocating for strategic policy frameworks to ignite private sector excitement in green energy enterprises. Different study segments have also highlighted the characteristics of the financial markets following the introduction of green bonds in various locations (Jiang et al., 2020; Li et al., 2015).

The body of studies advocates for the recalibrating of corporate and policy mindsets, highlighting a strategic junction between innovation and eco-conscious initiatives (B. Zhang & Wang, 2021). Thus, it follows that

Table 3: Most relevant authors and affiliations

Authors	Articles	Affiliation	Articles
Wang Y	24	Jiangsu University	34
Taghizadeh-hesary F	22	Wuhan University	27
Liu Y	21	Guizhou University of Finance and Economics	24
Li Y	17	Qingdao University	23
Li X	16	Shandong University of Finance and Economics	23
Zhang Y	15	Southwestern University of Finance and Economics	22
Zhang D	14	Nanjing University of Information Science and Technology	21
Sun Y	13	Tianjin Universityof Commerce	21
Wang Z	12	The Hong Kong Polytechnic University	20
Li J	11	Tokai University	20
Li L	11	China University of Mining and Technology	19
Zhang M	11	Dalian Maritime University	19
Chen H	10	Nanjing University of Aeronautics and Astronautics	19
Liu X	10	Shandong University	19
Liu Z	10	Rostov State University of Economics	18
Wang J	10	Capital University Of Economics and Business	17
Wang X	10	University Of International Business and Economics	17
Zhang H	10	Xiamen University	17
Zhang J	10	Beijing Technology and Business University	16
Zhang X	10	Nanchang University	16

Source: *Computed by author*

supporting low-carbon infrastructure is crucial, and that data-driven solutions and carbon commerce ecosystems should be prioritized (M. Zhang & Liu, 2022). In culmination, recent academic pursuits, as exemplified by (Y. Huang et al., 2022; D. Zhang et al., 2022), spotlight the dynamism of green innovation, advocating for a harmonized approach to bridge regional sustainability chasms under adaptive environmental guardrails.

B. Conceptual Structure

In tackling *RQ2* (What are the thematic evolution and conceptual development of the GSF research?), we delved into the key terms often used, their collaborative appearances, and undertook a comprehensive review of themes within this particular research area.

Most frequent keywords

Keyword analysis may be used to identify popular subjects for research (Bhatt et al., 2022). Between the years 2000 and 2023, a corpus of 50 papers on SF research was found. The word clouds in Figure 4 depict the main themes in each of these time periods as revealed by a temporal analysis. The expansion of GF, SF, "renewable energy," "climate change," "green bonds," "green innovation," "financial development," and "green economy" are also shown.

Co-occurrence analysis of the author's keywords

Co-occurrence research sheds light on the recurrent topics in GSF. Following primary themes resulted from the analysis of the keyword co-occurrence network (Figure 5).

Table 4: Most Relevant Country by Total Article, Total Citations and Average Citations per year

Country	TA	Country	TC	AC
China	1624	China	6656	13.30
Usa	256	Japan	1207	71.00
India	173	United Kingdom	1189	22.40
Malaysia	162	Usa	1086	19.70
Uk	162	Pakistan	757	22.30
Pakistan	158	Australia	724	24.10
Italy	148	Italy	666	17.50
Germany	130	Spain	460	20.90
Indonesia	111	India	432	9.40
Australia	107	France	420	23.30
Romania	98	Germany	396	9.90
Spain	74	Hong Kong	368	40.90
France	63	Malaysia	342	14.20
Poland	61	Brazil	268	26.80
Ukraine	55	Poland	240	11.40
Canada	53	Netherlands	228	20.70
Japan	53	Turkey	214	21.40
Brazil	50	Indonesia	182	6.70
Turkey	49	Singapore	178	12.70
Bangladesh	45	Romania	163	10.20

Note: *TA- Total Articles; TC- Total Citations; AC- Average Citations per year*

Source: *Computed by author*

- GF (in the context of "sustainable development", "green economy", "green innovation", "carbon emission", "environmental regulations", "Covid-19")
- SF (in the context of "sustainability", "climate change", "climate finance", "Environmental Social and Governance" (ESG), "sustainable development goals")

Thematic map

The framework proposed by (Callon et al., 1991) serves as a guide to understanding the field's thematic progression. Themes are arranged on this map based on two metrics: density and centrality. While density showcases the intensity of intra-theme connections, suggesting the theme's developmental depth, centrality highlights the theme's prominence and its inter-relations with other themes. From their placements on the map, themes can be identified as foundational, central, specialized, or either emerging or waning in importance. The visual representation of these themes is provided in Figure 6.

Motor themes: Themes that link other themes in the first quadrant are known as motor themes. The most important topics are those. Financial inclusion, green technology, human capital, and globalization have all facilitated "financial development," "economic growth and the environment," "energy consumption,"

Table 5: Most relevant document by global and local citations

Document	GC	Document	LC
Zhang D, 2021, Energy Policy	328	Sharif A, 2022, Sustainable Dev	2
Taghizadeh-hesary F, 2019, Finan Res Lett	308	Pham L, 2020, Finan Res Lett	1
Zhang X, 2011, J Clean Prod	272	Tu Canh, 2021, Singap Econ Rev	1
Campiglio E, 2016, Ecol Econ	268	Li G, 2022, Bus Strategy Environ	1
Glover Jl, 2014, Int J Prod Econ	267	Lee C-c, 2022, Energy Econ	1
Chan Apc, 2018, J Clean Prod	248	Wang Z, 2022, Economic Res Ekon Istraz	1
Flammer C, 2021, J Financ Econ	246	Hemanand D, 2022, Comput Intell Neurosci	1
Miroshnychenko I, 2017, J Clean Prod	187	Chin M-y, 2022, Environ Dev Sustainability	1
Tang Cf, 2014, Qual Quant	176	Prodan R, 2022, Proc - Ieee Cloud Summit, Cloud Summit	1
Gianfrate G, 2019, J Clean Prod	171	Chen Z, 2023, Renew Energy	1
Taghizadeh-hesary F, 2020, Energies	168	Ros Mfic, 2012, Isbela - Ieee Symp Bus, Eng Ind Appl	1
He B-j, 2018, Habitat Int	159	Banerjee A, 2019, Adv Sci Eng Technol Int Conf, Aset	1
Wedding Gc, 2007, J Environ Manage	159	Zhu Y, 2021, Proc - Int Conf Data Sci Bus Anal, Icdsba	1
Sun H, 2020, Sci Total Environ	153	Djukic G, 2021, Contemp Entrep Issues In Int Bus	1
Zhang S, 2021, J Environ Manage	152	Zhang D, 2021, Energy Policy	0
Irfan M, 2022, Technol Forecast Soc Change	136	Taghizadeh-hesary F, 2019, Finan Res Lett	0
Bartlett E, 2000, Build Res Inf	136	Zhang X, 2011, J Clean Prod	0
An S, 2021, Eur J Oper Res	135	Campiglio E, 2016, Ecol Econ	0
Kiefer Cp, 2019, Bus Strategy Environ	134	Glover Jl, 2014, Int J Prod Econ	0
Li S, 2016, Int J Prod Res	134	Chan Apc, 2018, J Clean Prod	0

Note: GC: Global Citations; LC: Local Citations

"natural resources," and "environmental degra-dation." The relationship between "economic growth," "energy consumption," "natural resources," and "environmental degradation" has grown significantly. Utilization of "natural resources," "environmental impact," and "energy consumption" all have complex impli-cations on "economic development." When properly managed, they increase productivity and propel industries. For sustainable, inclu-sive economic development that reduces unfavorable effects and helps both the current and future generations, it is crucial to strike a balance between efficient energy usage, responsible resource management, and environmental protections. Given its significance, the topic has grown in depth and become more essential, with strong connections to other significant concepts. From a fundamental subject, the function of SF, "green bonds," and "climate change" in "economic development" has developed into a driving theme.

Basic themes: The topics in the fourth quadrant are the basic themes. They are very pertinent to the corpus of study as a whole. Although they have strong connections to other

Table 6: Author's Production by total citations and total citations per year

Author	Year	TI	SO	DOI	TC	TCpY
Taghizadeh-hesary F	2021	"Public Spending and Green Economic Growth in Bri Region: Mediating Role of Green Finance"	Energy Policy	10.1016/ j.enpol. 2021.112256	328	109.3333
Zhang D	2021	"Public Spending and Green Economic Growth in Bri Region: Mediating Role of Green Finance"	Energy Policy	10.1016/ j.enpol. 2021.112256	328	109.3333
Taghizadeh-hesary F	2019	"The Way to Induce Private Participation in Green Finance and Investment"	Finance Research Letters	10.1016/ j.frl.2019. 04.016	308	61.6
Taghizadeh-hesary F	2020	"Sustainable Solutions for Green Financing and Investment in Renewable Energy Projects"	Energies	10.3390/ en13040788	168	42
Wang Y	2021	"Fostering Green Development with Green Finance: An Empirical Study on the Environmental Effect of Green Credit Policy in China"	Journal of Environmental Management	10.1016/ j.jenvman. 2021.113159	152	50.66667
Taghizadeh-hesary F	2022	"Role of Green Finance in Improving Energy Efficiency and Renewable Energy Development"	Energy Efficiency	10.1007/ s12053-022- 10021-4	111	55.5
Li J	2015	"Building Green Supply Chains in Eco-industrial Parks Towards A Green Economy: Barriers and Strategies"	Journal of Environmental Management	10.1016/ j.jenvman. 2015.07.030	101	11.22222
Li X	2020	"The Market Reaction To Green Bond Issuance: Evidence From China"	Pacific Basin Finance Journal	10.1016/ j.pacfin. 2020.101294	98	24.5
Liu Y	2020	"Green Bonds for Financing Renewable Energy and Energy Efficiency Iin South-east Asia: A Review of Policies"	Journal of Sustainable Finance and Investment	10.1080/ 20430795. 2019.1704160	63	15.75
Taghizadeh-hesary F	2021	"Analyzing the Characteristics of Green Bond Markets to Facilitate Green Finance in the Post-covid-19 World"	Sustainability (Switzerland)	10.3390/ su13105719	59	19.66667
Wang Y	2021	"The Effect of Green Finance on Energy Sustainable Development: A Case Study in China"	Emerging Markets Finance and Trade	10.1080/ 1540496X. 2019. 1695595	56	18.66667

Contd.

Author	Year	TI	SO	DOI	TC	TCpY
Zhang D	2021	"How Does Innovation Efficiency Contribute to Green Productivity? A Financial Constraint Perspective"	Journal of Cleaner Production	10.1016/j.jclepro.2020.124000	54	18
Zhang D	2021	"The Causal Effect on Firm Performance of China's Financing–Pollution Emission Reduction Policy: Firm-level Evidence"	Journal of Environmental Management	10.1016/j.jenvman.2020.111609	54	18
Liu Y	2022	"Influence of Digital Finance and Green Technology Innovation on China's Carbon Emission Efficiency: Empirical Analysis Based on Spatial Metrology"	Science of The Total Environment	10.1016/j.scitotenv.2022.156463	49	24.5
Wang Y	2020	"The Measurement of Green Finance Development Index and its Poverty Reduction Effect: Dynamic Panel Analysis Based on Improved Entropy Method"	Discrete Dynamics in Nature and Society	10.1155/2020/8851684	45	11.25
Wang Y	2021	"Sustaining The Sustainable Development: How Do Firms Turn Government Green Subsidies into Financial Performance Through Green Innovation?"	Business Strategy and the Environment	10.1002/bse.2746	43	14.33333
Liu Y	2023	"Research on the Emission Reduction Effects of Carbon Trading Mechanism on Power Industry: Plant-level Evidence from China"	International Journal of Climate Change Strategies and Management	10.1108/IJCCSM-06-2022-0074	41	41
Taghizadeh-hesary F	2022	"Does Green Finance Counteract the Climate Change Mitigation: Asymmetric Effect of Renewable Energy Investment and R&D"	Energy Economics	10.1016/j.eneco.2022.106183	38	19
Zhang D	2022	"Does Green Finance Counteract the Climate Change Mitigation: Asymmetric Effect of Renewable Energy Investment and R&D"	Energy Economics	10.1016/j.eneco.2022.106183	38	19
Zhang Y	2022	"Impacts of Green Finance on Green Innovation: A Spatial and Nonlinear Perspective"	Journal of Cleaner Production	10.1016/j.jclepro.2022.132548	37	18.5

Note: *TI- Title; SO- Source; DOI; Date of Issue; TC- Total Citations; TCpY- Total Citations per Year*

Source: *Computed by author*

RQ2: What are the thematic evolution and conceptual development of the green and sustainable finance research?

Figure 4: Word cloud of most frequent author's keywords in the field of green and sustainable finance

Source: *Computed by author*

Figure 5: Keyword co-occurrence network

Source: *Computed by author*

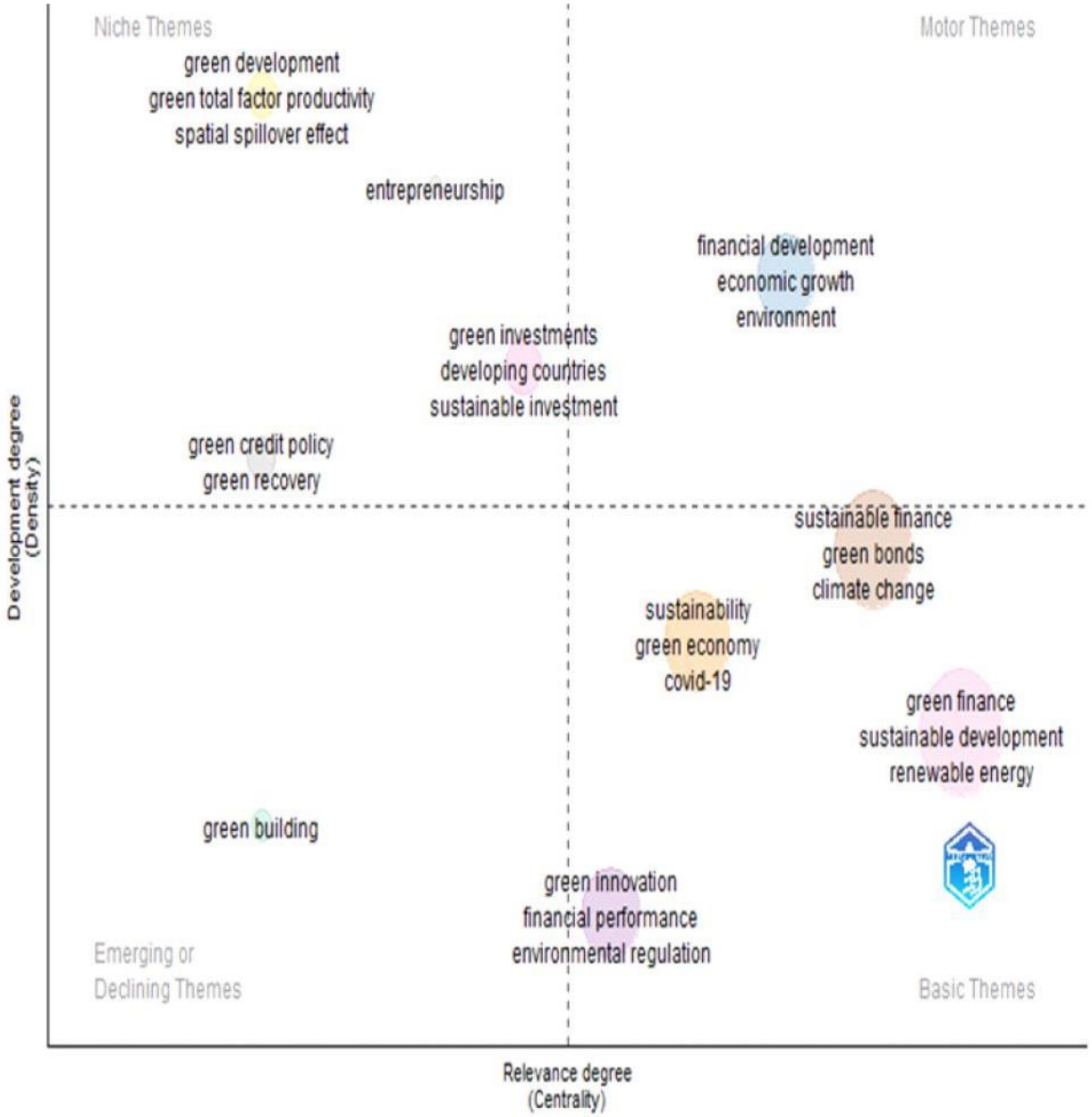


Figure 6: Thematic Map

Source: *Computed by author*

topics, they experience stasis and do not progress smoothly. GSF have arisen as essential issues driven by "sustainable development" and "renewable energy," "sustainability" driven by "green economy," and "covid-19." These are significant topics that are connected to other themes and are closely related to them.

Niche themes: The upper left quadrant is reserved for niche topics, which are highly developed and specialized subjects that are only marginally related to other themes. By encouraging eco-friendly projects and practices, "green credit policy" and "green investment" played a significant part in driving GSF. Financial institutions are encouraged by "green credit policies" to provide favorable terms to enterprises that fulfill certain environmental requirements, which encourages companies to engage in green projects and embrace sustainable business practices. In contrast,

"green investments" include allocating funds to initiatives that have a good influence on the environment, promote innovation, create jobs in environmentally friendly industries, and solve ecological issues while creating profits. Together, these initiatives promote a shift to a more resilient and environmentally conscien-tious economy while also promoting economic development, risk reduction, transparency, social well-being, and long-term sustainability.

Emerging or declining themes:The marginal themes – emerging and declining – are not adequately developed nor very relevant nor cohesive with the other topics. These topics are either developing or fading. The infrastructure sector has been looking for "green transfor-mation," which has arisen as an emerging subject, as a result of the "GF" industry's ever-increasing involvement in "sustainable deve-lopment."

Thematic evolution

The study of theme evolution in the context of the field considers the overall picture of how the field has evolved over time. The entire time period is divided into several time slices in order to do this. Based on the centrality and density of the author's keywords and the fields, it serves as a compass that guides the growth of the study field. The theme evolution map is created by applying a clustering algorithm to the keyword network, which consists of the numerous subjects that relate to a certain domain (Figure 7). The total number of published works has been used to determine the time-cutting milestones, which are 2008 and 2015.

The years 2008 and 2015 were deliberately selected as key intervals for examining the

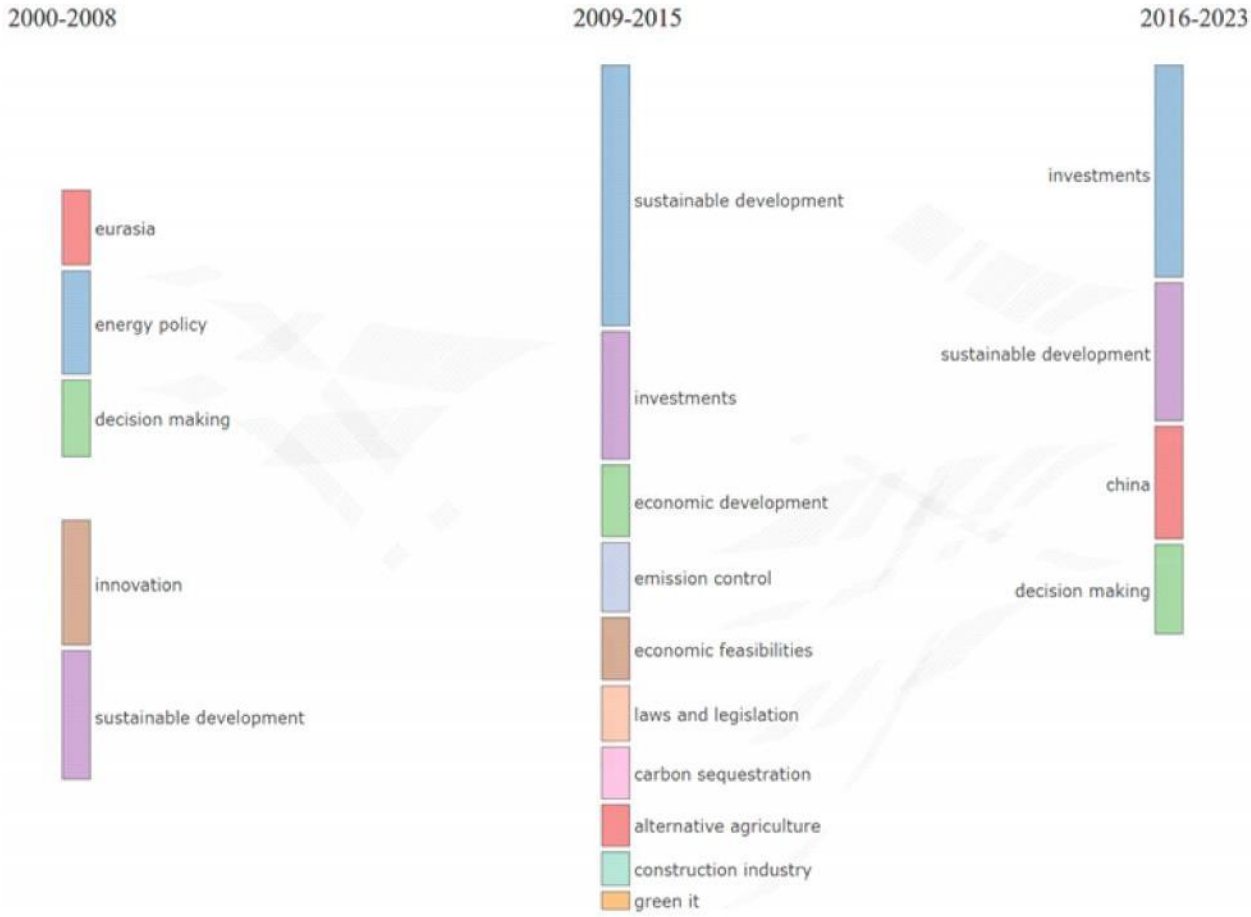


Figure 7:Thematic Evolution Map

Source: *Computed by author*

theme development in the GSF discipline. Key occasions and notable breakthroughs in sustainability and finance informed the selection process. There has been a reassessment of what it means to make ethical and prudent financial decisions in the wake of the 2008 financial crisis. Academics were probably forced to consider the idea of integrating sustainability issues into finance as a potential crisis solution following this incident. The subsequent passage of the Paris Agreement marked a turning point in 2015 as the international community committed to combating climate change. Following this watershed moment, several industries, including banking, heightened their awareness of the importance of sustainable practices and environmental concerns. Academic interest in science fiction (SF) and collaborative efforts in the field surged between 2008 and 2015. Studying theme progression over this epoch is incredibly important because it reveals how sustainability and finance interact in reaction to big global events. This is especially true in current age of growing interest.

It is the first time that the words "innovation," "sustainable development," and "energy policy" have been treated as distinct groups (2000-2008). But in the second time period, from 2009 to 2015, they combine to form the main keywords "sustainable development" and "investments." Not only that, but GSF changed a lot over that time. Studies of feasibility, emission control, and carbon sequestration were prompted by an emphasis on ecologically responsible economic growth that occurred after the 2008 financial crisis. ESG reporting and responsible investing were encouraged by legislative measures. Growing concern about climate change directed funding towards emission reduction initiatives. Valuation of natural capital and carbon sequestration gained prominence. This transformative period intertwined finance and sustainability, harmonizing economic advancement with environmental conscientiousness. In the next slice, "sustainable development", is ranked second with "*investments*" keywords emerging as the most popular topics in 2009 and beyond. The authors' articles appear on many occasions in all three time slices that contain the term "*GSF*."

C. Intellectual Structurem

We offered a co-citation network and a content analysis of the most relevant papers to address *RQ3* (What is the current intellectual structure of GSF research?).

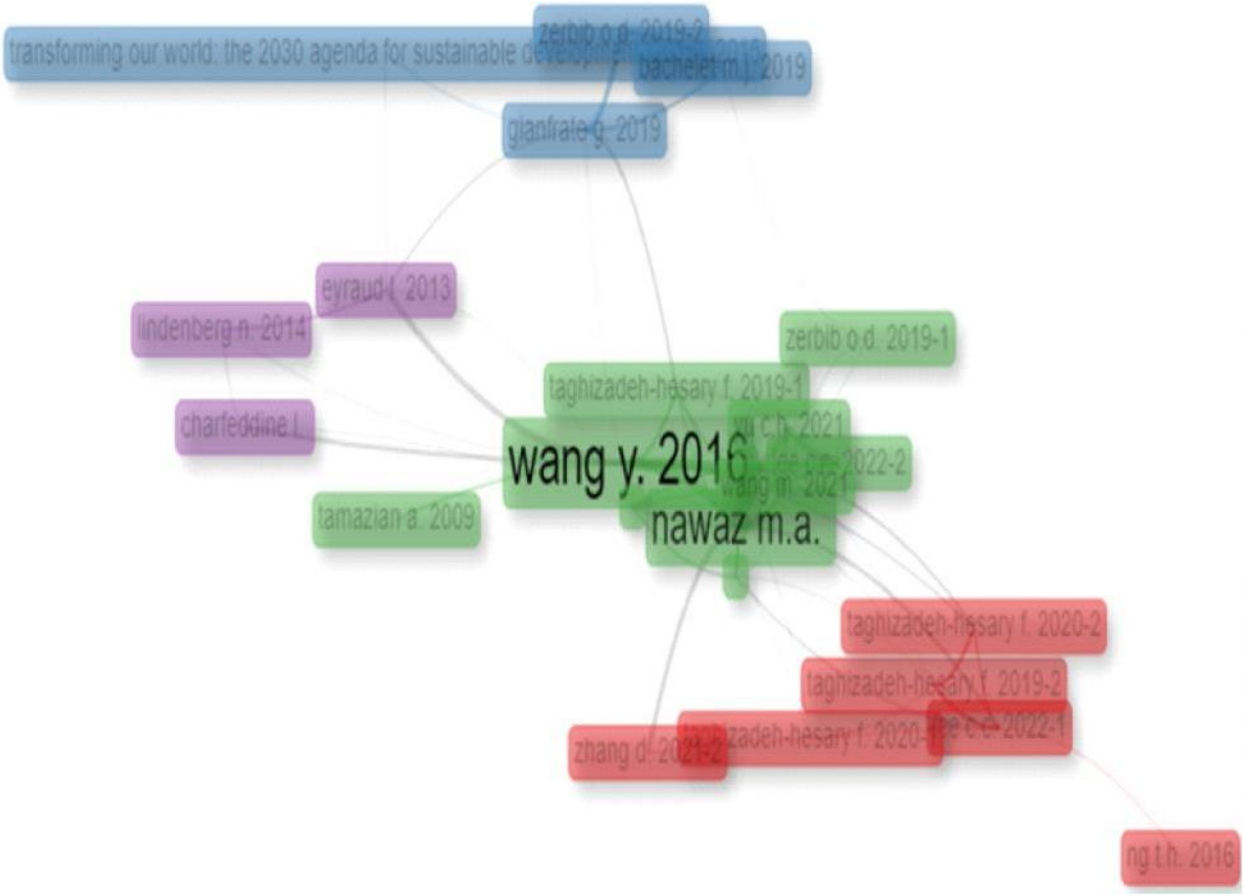
Co-citation and content analysis

A co-citation shows how often two articles are referenced together (Small, 1973). The structure, trends, and advances in a research area are well shown by this study (Z. Liu et al., 2015). The co-citation network of papers in GSF is shown in Figure 8. The size of the node indicates the quantity of citations, and the thickness of the connection between two texts indicates the significance of the co-citation. Four groups of papers that were co-cited developed. Documents by (Gianfrate & Peri, 2019; Lee et al., 2022; Taghizadeh-Hesary & Yoshino, 2019, 2020; Zerbib, 2022; D. Zhang & Vigne, 2021) provide a theoretical or methodological foundation for GSF make up the bulk of the green literature.

Using a combination of methods such as a thematic map, word cloud analysis, topic evolution, co-citation network analysis, and full-text evaluation of the selected most important journal articles, four streams are identified.

I. **Reducing costs and increasing profits through ESG integration in business:** Improving financial decision-making with ESG (environmental, social, and governance) considerations is an attractive issue that researchers are exploring. Their research is examining the potential correlation between corporate governance standards and a company's social responsibility, environmental impact, and financial performance. This stream also tackles the complex task of assessing the concrete financial advantages of integrating these sustainability elements.

II. **Disruptive techniques for enduring investment over an extended period:** Innovative financial solutions can facilitate investments that have a positive impact on society and the environment. Green bonds and sustainability-linked loans are novel financial opportunities for enterprises with a social and environmental



RQ3: What is the current intellectual framework for research in green and sustainable finance?

Figure 8: Co-citation network of documents

Source: *Computed by author*

agenda. Researchers are examining these techno-logies to determine if they can strike a balance between immediate financial gains and long-term societal and ecological advantages, and if they can persuade investors to support environmentally friendly initiatives.

III. Circumventing laws and regulations: A select few scholars are actively engaging with the complex regulations that govern the realm of science fiction. Ayesha and Chellaswamy (2023) want to examine how government rules, international agreements, and industry standards interact with each other in order to promote financially responsible practices that are mindful of both ecological and social considerations. In this section, we will examine how these policies facilitate ethical investment practices, enhance public disclosure, and address climate change issues.

IV. Combining the Ingredients: Opinions from Around the World and International Links: Here, specialists in areas as varied as economics, law, and environmental studies gather to examine SF from several perspectives. When it comes to creating a society that is both sustainable and environmentally conscious, academics are striving to bridge many fields of study so that we can see the bigger picture. In addition, they are looking at how scientists and scholars from different parts of the world collaborate to exchange ideas and put plans into action that might advance science fiction internationally.

Table 7: Co-citation network of document and clusters

Document	Cluster	Betweenness	Closeness	PageRank
lee c.c. 2022-1	1	29.49857143	0.00952381	0.051041709
taghizadeh-hesary f. 2020-1	1	54.41454545	0.012048193	0.030481511
taghizadeh-hesary f. 2019-2	1	26.3914985	0.010309278	0.043407006
ng t.h. 2016	1	0	0.004651163	0.013247654
taghizadeh-hesary f. 2020-2	1	42.31252747	0.011764706	0.033153173
zhang d. 2021-2	1	0	0.009174312	0.015855462
gianfrate g. 2019	2	55.70330249	0.011904762	0.054912584
transforming our world: the 2030 agenda for sustainable develop-ment (2015). 2015	2	0	0.009259259	0.015932687
zerbibo.d. 2019-2	2	0	0.005434783	0.042237275
bacheletm.j. 2019	2	7.382857143	0.005847953	0.035279365
wang y. 2016	3	140.7075804	0.01369863	0.090727561
nawazm.a.	3	70.10216783	0.011494253	0.08781077
zhang d. 2021-1	3	37.1590573	0.011494253	0.101029266
he l. 2019	3	4.123876124	0.00877193	0.036107107
lee c.c. 2022-2	3	0	0.006329114	0.045822521
taghizadeh-hesary f. 2019-1	3	1.649122807	0.009615385	0.035527778
yuc.h. 2021	3	0	0.006329114	0.049949809
zerbibo.d. 2019-1	3	7.679554656	0.005847953	0.015611696
tamazian a. 2009	3	0	0.005464481	0.012748744
wang m. 2021	3	3.637243108	0.01010101	0.070171977
jin y. 2021	3	1.238095238	0.009708738	0.042339389
charfeddine l.	4	5.777777778	0.010752688	0.018328422
lindenberg n. 2014	4	0	0.010526316	0.030140116
eyraud l. 2013	4	34.22222222	0.011627907	0.02813642

Source: *Computed by author*

Researchers in the field of "Bibliometric Analysis of GSF." are using diverse techniques, as shown by the four streams. This fascinating topic may serve as a foundation for a more sustainable and economically secure future, and each stream delves into a unique aspect of it.

Discussion And Future Directions

Discussion

Taking a look at the theoretical underpinnings of GSF studies reveals a diverse and dynamic field. We can obtain a detailed understanding of the most popular research subjects and ideas through extensive content analysis and co-citation networks.

1. **ESG Factors:** Foundational to Financial Sustainability Contemporary finance is undergoing a revolutionary shift due to the introduction of ESG (environmental, social, and governance) factors into financial

results. It used to be normal practice to disregard the correlation between long-term viability and economic prosperity. This emerging academic discipline now indicates a pivotal change. Investors and institutions are realizing how closely sustainability and long-term financial success are related. This change begs the question, "How can businesses integrate ESG elements in a harmonious way?" To what extent do ESG practices influence investor decisions?

2. **Emergence of Sustainable Financial Tools:** The financial sector's adaptability is shown in the creation and analysis of novel financial mechanisms. Investment paradigms are redefined and funds are directed towards beneficial activities using instruments such as sustainability-tied loans and green bonds. Even though they clearly have potential, further research is needed to determine their long-term effects and potential drawbacks. Do these systems reliably guarantee returns that are competitive? How might they change in the future to appeal tomore people?

3. **Handling the Regulatory Labyrinth:** The complex web of rules, regulations, and laws influencing SF highlights the connection between market forces and governance. It is encouraging to watch scholars analyze this intricate system. However, ongoing monitoring is essential due to the dynamic character of policies driven by world events, climatic issues, and economic changes. Future research might consider the following: How can we create robust, flexible policies that focus on sustainability? What role does international collaboration play in bringing disparate regulations into line?

4. **The Importance of International Collaborations and Multidisciplinary Perspectives:** It is rather energizing to see how enthusiastic people are about a multi-disciplinary approach in the current research environment. SF is a synthesis of many academic disciplines rather than being restricted to a single specialty. The integration of diverse sectors and the promotion of global collaborations augment the profundity of research discoveries. What other tactics can be used to strengthen these interdisciplinary connections? What dynamics emerge when diverse field experts come together on SFissues?

The intellctual exploration of GSF research is a dynamic blend of interconnected themes and methodologies. With sustainability becoming even more critical in future narratives, this research area is set for significant expansion. The structure and themes we've discussed provide a blueprint for academics, industry professionals, regulators, and investors. Combining scholarly endeavors with practical applications can drive a more comprehensive evolution of the field, responsive to current needs and future challenges.

Future Directions

The landscape of GSF has grown remarkably. Our exploration sets the stage for anticipating subsequent advancements. While there's an uptick in studies centered on GSF, untouched research niches persist. In response to *RQ4* (Which areas of GSF merit additional research?), we pinpointed specific domains ripe for further inquiry. Venturing into the nuanced interactions of financial strategies, ESG factors, pioneering methods, guiding principles, and inter-sectoral discussions uncovers vast areas primed for deeper investigation.

1. **Advancing ESG Protocols:** The importance of ESG parameters in today's businesses is unmistakable. The road ahead might involve enhancing and broadening the criteria that evaluate ESG impacts. This calls for a new wave of studies centered on devising transparent, inclusive, and globally recognized ESG evaluative measures suitable for diverse business environments (Aburto Barrera & Wagner, 2023; Hammond & O'Brien, 2021).

2. **GF in Growth Markets:** Much has been said about the practices in mature markets, but the untapped potential lies in the blossoming economies. Examining sustainable financial mechanisms in these regions can unearth distinct challenges and

opportunities (Mustafa et al., 2022).

3. **Fusion of Technology with Green Initiatives:** As the world becomes increasingly digitized, SF cannot remain aloof. Anticipating how emerging technologies like AI, blockchain, and data science can refine green investments, ensure real-time ecological impact monitoring, and elevate the clarity of sustainable tools will be pivotal (Ahmad & Looy, 2020; Felicetti et al., 2023; Nottbrock et al., 2023; Satalkina & Steiner, 2020).

4. **Finance in the Climate Era:** The undeniable repercussions of climate variations challenge economic structures. Probing how financial frameworks can adapt to these dynamic changes will be paramount. Understanding the fiscal repercussions of environmental fluctuations will be a necessity (H. H. Huang et al., 2022; Rising et al., 2022; Secinaro et al., 2020).

5. **Global Green Collaboratives:** Sustainability knows no boundaries. With shared ecological concerns, the potential for international cooperative ventures in GF becomes ever more apparent. This poses a golden opportunity to research globally harmonized practices, uniform standards, and transnational green investment avenues (Ren et al., 2023; Zhu et al., 2023).

6. **Beyond Numbers - The Ethical Dimension:** While financial aspects dominate the discourse, the humane side of SFdemands attention. The moral, social, and ethical ramifications and obligations of financial entities in guiding a green transition are fertile grounds for exploration (Richardson, 2009; Ryan et al., 2010).

7. **Responsive Regulatory Mechanisms:** In a field as dynamic as SF, stagnant policies won't suffice. The future demands research into evolving, agile, and encompassing policy structures that keep pace with the sector's vibrancy.

8. **Nurturing Future Green Financiers:** With the financial landscape undergoing transformation, there's an imperative to prepare the coming generations. Initiatives might focus on crafting holistic academic courses that seamlessly blend SF theories with hands-on applications.

The initial strides in GSF have been commendable, yet the journey ahead is vast and filled with promise. In addition to enhancing academic endeavors, embracing new difficulties and seizing opportunities will direct global economic systems toward sustainability, inclusion, and resilience.

Conclusion

The GSF journey, as described in our paper, emphasizes the importance of a financially motivated ethical and ecologically conscientious environment. This study has skillfully weaved a tapestry that illustrates how business and academia are negotiating the challenging landscapes of cutting-edge financial tools, regulations that are always changing, and the integration of ESG. Every area we examined demonstrates the broader dedication to a global financial system that places an emphasis on environmental sustainability.

A feeling of buoyant optimism permeates anticipations of future directions. It appears that technical advancements, environmental goals, niche market tactics, flexible policy frameworks, and a spirit of international collaboration will soon come together. In addition, the emphasis is gradually moving from narrow measures of profit to a wider range of environmental and social responsibility. To sum up, GSF represents a paradigm change rather than just a trendy term from today. Researchers, legislators, and financial specialists have come together with a same vision: A financial architecture that values prosperity, the environment, and people equally. The groundwork has been laid by this transformative era, and the future holds a myriad of sustainable prospects and solutions.

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