A bibliometric-qualitative literature review of green finance gap and future research directions

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Abstract

Green finance (GF) supports the global fight against climate change and its impacts. It is critical to attaining the Paris Agreement and the United Nations Sustainable Development Goals. Since GF is regarded as the future of finance and investment, it needs to be *fully* understood. This paper presents the *first* mixed-methods systematic review with both bibliometric and qualitative analysis of the state-of-the-art and trends in GF research. A bibliometric review was performed to quantitatively examine the main areas of interest, journals, and clusters of GF research based on 995 related publications retrieved from Scopus and validated with the Web of Science, Google Scholar, and ScienceDirect. Results showed that GF is still relatively an immature but interdisciplinary research area. A further qualitative-systematic analysis of 60 selected publications was conducted to identify the key findings, challenges, and recommendations for future research. Findings revealed six major research hotspots in GF: (i)

green bond market and greenium, (ii) green credit (loan), (iii) carbon investment and market, (iv) green banking, (v) market stress (e.g., the COVID-19 pandemic) and GF, and (vi) domestic and international climate finance policies. Based upon gaps in extant literature, suggestions for future research are proposed: GF policy initiatives and incentives; GF in green building; and Fintech-for-GF. This study provides insights into key applications of GF as it applies to specific research fields, as well as the pathways to realize the accruable benefits of GF to enhance research and development.

Keywords: Green finance, Sustainable finance, Qualitative analysis, Bibliometric analysis, Mixed-methods systematic review.

1. Introduction

Today's world faces many severe environmental challenges such as air pollution, scarcity of resources, and land degradation which have implications for productivity, economic success, and public health (UNEP, 2017). To overcome these, sustainable development towards a green economy has become a mainstream consideration for the financial sector (International Capital Market Association (ICMA), 2020). Green economic transition demands huge investments that protect the environment with its benefits – the case of *green finance* (GF). GF refers to "financial services provided for economic activities that are supportive of environment improvement, climate change mitigation and more efficient resource utilization. These economic activities include the financing, operation and risk management for projects in areas such as environmental protection, energy savings, clean energy, green transportation, and green buildings" (EIB and GFC, 2017 p.8). GF is a broad concept of *sustainable finance* for socially inclusive green projects, *environmental finance* to promote environmentally responsible investments, *carbon finance*, targeting reduction in greenhouse gas (GHG) emissions, and *climate finance*, focusing on climate change mitigation and adaptation initiatives (Noh, 2019). It covers a wide range of instruments, from private loans to insurance, and includes equity, derivatives, and fiscal or investment funds (Taghizadeh-Hesary et al., 2021). GF is crucial to achieving the Paris Agreement (UNFCCC, 2015) and the United Nations Sustainable Development Goals (UNEP, 2018).

Hence, GF has received increasing attention from researchers, national governments, and international organizations, leading to increasing empirical studies (e.g., MacAskill et al., 2021; Ferrer et al., 2021). Alongside, some review studies have been published. However, most of them focus on the application of GF to a specific sub-sector, such as green banking (Akomea-Frimpong et al., 2021; Sarma & Roy, 2021), renewable energy (Hafner et al., 2020), and green buildings (Debrah et al., 2022a). For instance, Debrah et al. (2022) conducted a "scoping review" of only 28 studies on the "implementation of GF in green buildings". Akomea-

Frimpong et al. (2021) presented a "content analysis" of only 46 studies on "GF of banks". Similarly, Sarma & Roy (2021) conducted an "exploratory and descriptive" review of only 178 studies on "green banking". Hafner et al. (2020)'s review explored only 31 policy reports and 73 research articles on the barriers to "large-scale clean energy infrastructure investment" in developed countries. Other review studies focused on a typology of GF such as green bonds and green loans (Bhutta et al., 2022; Gilchrist et al., 2021; MacAskill et al., 2021). Above-mentioned reviews offer a narrowed perspective rather than a general, inclusive understanding of GF research. Moreover, they are based on qualitative manual analysis of the literature which is prone to subjective biases, lack of replicability, and decreased reliability (Darko et al., 2020; Pan & Zhang, 2021). While few recent reviews (Cai & Guo, 2021; Yu et al., 2021; Zhang et al., 2019) have attempted to address these limitations via quantitative-bibliometric approach, they also lack the *in-depth* understanding that qualitative approach could afford. To overcome the limitations of both the quantitative-bibliometric and qualitative approaches to achieve more valid and reliable analysis and understanding of GF research, there is a need to integrate the benefits of both approaches. Such a review is currently missing from the GF literature.

To fill this gap, this study aims to provide a mixed-methods bibliometric-qualitative review of GF research for the first time. Unlike previous reviews that had narrowed perspectives, this review focuses on GF in general. To enhance the *depth and breadth* of understanding, this review addresses the following limitations of previous reviews: (1) searching multiple literature databases using a combination of multiple keywords to identify the relevant body of knowledge (Section 2), leading to 995 publications; (2) first, performing quantitative bibliometric analysis to summarize the evolution of the literature, structure and networks of GF body of knowledge, evaluating the depth of scientific collaboration in GF research (Section 3); (3) then, providing an in-depth understanding of the research hotspots and application areas of GF via a qualitative-systematic analysis (Section 4); and (4) finally, identifying the signposts for future research to accelerate the development and impact of GF (Section 5).

2. Research methodology

The “mixed-methods systematic review” was the primary method adopted for this study. This method incorporates both quantitative review (i.e., bibliometric approach) and systematic review (i.e., qualitative approach) in a single research (Oraee et al., 2017) for synthesizing and analyzing available literature on a subject (Harden & Thomas, 2010). The mixed-methods systematic review has the ability to reduce biased conclusions and subjective judgments and interpretations, as well as “to enhance the depth-and-breadth of understanding” in comparison to the “mono-method manual systematic review”(Heyvaert et al., 2016). Like previous studies (Yin et al., 2019), this study utilized the mixed-methods systematic review to overcome shortcomings and build on the strengths of both quantitative and qualitative methods when used in isolation. Also, the challenge of biased and subjective judgement and interpretations (Harden & Thomas, 2010) could be addressed with the mixed-method systematic review. According to Heyvaert et al. (2016), this research approach must follow an outlined protocol in terms of data collection and analysis to achieve the defined objectives of the study. Figure 1 provides a summary of the guidelines for conducting a mixed-method systematic review, details of which are discussed next.

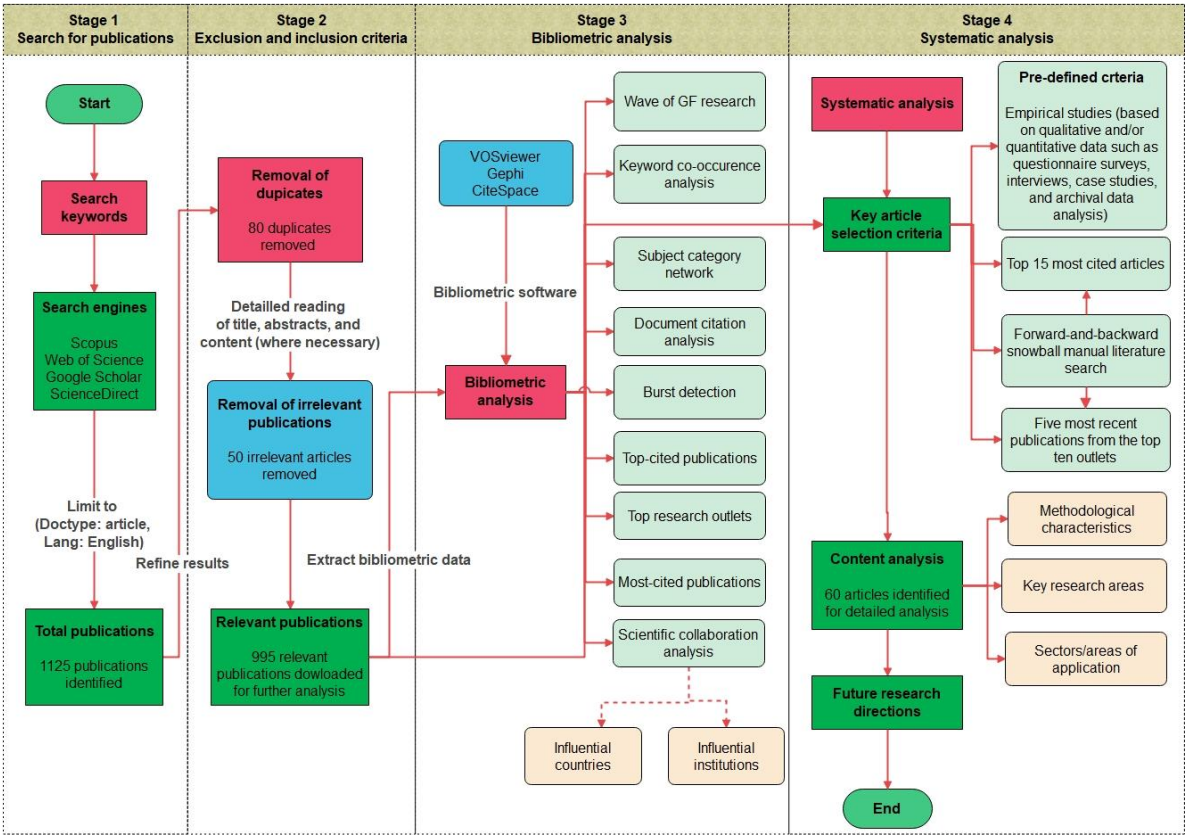


Figure 1. Research methodology (modified from Debrah et al., 2022b).

2.1. Search for publications (stage 1)

As illustrated in Figure 1, the first stage of this study involved the search for publications. A data collection strategy of previous literature is necessary to retrieve relevant data since it defines the knowledge framework upon which research conclusions are based. Therefore, it is critical to include all the known research terms based on past research to increase the quality and validity of the data. We however acknowledge that it is impossible to include all likely terms in one study (Darko & Chan, 2016). Keywords combination from the literature (Akomea-Frimpong et al., 2021; Hafner et al., 2020; Zhang et al., 2019) were used to retrieve bibliographic data. The Scopus, Web of Science, Google Scholar, and ScienceDirect databases were selected for data identification due to their high coverage of high impact publications. Since the Scopus has higher indexing rate with wider and more recent publications coverage than other databases (Meho & Rogers, 2008), it was selected as the primary data source while the rest were employed to fully download the article and validate the data. It has also been

widely used in the literature (Debrah et al., 2022a, 2022b). To provide a comprehensive database, searches were performed in the "title", "abstract", and publication "keywords" sections with no date range restrictions. As of 13 March 2021, 1,125 publications were initially identified and downloaded. Table 1 shows the search parameters for document retrieval.

Table 1. Search data parameters for document retrieval

Parameter	Settings
TITLE-ABS-KEY	("Green finance" OR "Climate finance" OR "Sustainable finance" OR "Carbon finance" OR "Environmental finance" OR "Carbon financing" OR "Sustainable financing" OR "Green bonds" OR "Climate bonds" OR "Green investing" OR "Eco-investing" OR "Carbon investing" OR "Green credit" OR "Green loan" OR "Green securities")
Type	Article
Time span	No limitations (1989 to March 2021)
Language	English

Note. TITLE-ABS-KEY = Title, abstract and keywords

2.2. Exclusion and inclusion criteria (stage 2)

Regarding the exclusion and inclusion criteria, the "document type" was limited to "article". This is because compared to other document types such as conference papers, articles commonly have higher quality due to their relatively rigorous peer-review process. Moreover, articles offer a more authoritative body of knowledge for bibliometric analysis (Darko et al., 2020; Debrah et al., 2022b). The CiteSpace function was used to remove 80 duplicate publications from the initial dataset. Further, 50 irrelevant publications were removed after reading of titles, abstracts, and in some cases, the full content of the initially identified publications, where the abstracts failed to provide sufficient information. The manual screening process was used to exclude all the research papers that were outside the scope of this study and further not duplicated using CiteSpace. Eventually, the dataset for this study included 995 relevant publications. Publications in languages other than "English" were outside the study's scope.

2.3. Bibliometric analysis (stage 3)

The bibliometric approach refers to the mapping and visualization of large scientific dataset (van Eck & Waltman, 2014), which is useful in studying and comprehending the structural and dynamic features of a scientific domain (Darko & Chan, 2021). Bibliometric analysis uses networks to represent how scientific or research domains are structured socially, conceptually, and intellectually (Cobo et al., 2011). In line, this study employed the bibliometric analysis to identify the knowledge domains, research trends, and main research outlets regarding GF. Like any robust bibliometric study (Cobo et al., 2011), multiple bibliometric software were utilized synergistically to analyze the data. VOSviewer 1.6.17, Gephi 0.9.2, and CiteSpace 5.8.R3 software were cooperatively used for analyzing the data and, developing and visualizing the knowledge maps. While VOSviewer provides distance-based visualizations of bibliometric networks to indicate relatedness (van Eck & Waltman, 2014), Gephi has the ability to visualize all kinds of networks (Bastian et al., 2009). Likewise, CiteSpace is useful for analyzing and visualizing emerging trends in a body of knowledge and their interrelatedness (Chen, 2006). The combined use of VOSviewer, Gephi, and CiteSpace allow data analysis at higher quality (Oraee et al., 2017). Thus, in stage 3, VOSviewer, Gephi, and CiteSpace were used for bibliometric analysis, forming the basis for the qualitative-systematic analysis in stage 4.

2.4. Systematic analysis (stage 4)

The qualitative-systematic analysis stage of carefully selected papers (see Figure 1) was based on the proposal by Harden and Thomas (2010) for mixed-methods systematic analysis. This analysis is effective in revealing knowledge gaps and suggesting areas for future studies towards advancing knowledge (Oraee et al., 2017). Adopting this method helps to triangulate and elaborate the study results (Greene et al., 1989). Hence, the mixed-methods systematic analysis has been developed to reveal the full picture of GF knowledge while isolating key areas for in-depth analysis.

169 The *pre-defined criteria* for selecting key literature in the systematic analysis stage are as
170 follows: only empirical studies were eligible for the in-depth systematic analysis. By *empirical*
171 *studies*, we refer to the qualitative and/or quantitative analysis of data collected from methods
172 such as questionnaire surveys, interviews, case studies, and from archival databases. Antwi-
173 Afari et al. (2021) and Kirchherr & van Santen (2019)'s approaches were followed to select
174 key articles for the in-depth systematic analysis. In this regard, this paper considered the
175 following steps. We first selected the 15 most cited GF publications. Second, we selected the
176 five most recent publications of the top ten GF journals (Table 6). Finally, using a manual
177 forward-and-backward snowball search, 35 studies were randomly selected according to their
178 importance in the literature. In the *backward snowballing*, relevant studies were identified from
179 the reference list of the initial set (first and second steps above). The discovered studies formed
180 a new set to undergo the same process referred to as *forward snowballing*. This cyclical process
181 of backward-and-forward snowballing was repeated till no new studies were found.
182 After deduplication and evaluation of the resulting studies according to the pre-defined
183 criteria (i.e., empirical studies), a total of 60 articles were finally found eligible for further
184 analysis. Consistent with previous studies (Oraee et al., 2017; Yin et al., 2019), the qualitative-
185 systematic analysis comprised a *content analysis* of concepts, themes, theories, developments
186 and research focuses of the carefully selected papers. This was facilitated by an in-depth
187 content analysis to provide insights into GF, identify research gaps, and provide directions for
188 further research. Given the systematic approach adopted, we believe that our sample is
189 representative of the now-available GF literature. However, we do not claim to present an
190 exhaustive overview of the GF literature. All articles examined are listed in the Appendix A.
191

192 ## 3. Bibliometric analysis

193 ### *3.1. Wave of GF research*

The first study of the dataset related to GF turned out to be Feldman (1989)'s, "Paying for cleanup: tools for confronting environmental finance issues", published in the *Journal of the Air Pollution Control Association*. Figure 2 indicates the trend of GF publications from 1989-2021; where there are more publications in the 21st century (2001-2021) than in the 20th century (1989-2000). Noticeably, in contrast to the slow steady growth of GF research in the 20th century, the number of relevant publications has increased significantly from 2009 to present. The current appreciable interest from academics on GF research could be due to the establishment of the Kyoto Protocol (in 2009) and the Paris Agreement (in 2015). Since the literature search was conducted on 13 March 2021, it is expected that the number of publications in 2021 may increase at the end of the year as suggested by the rising citations (*blue line*) and the Gompertz function (*green line*) (see Figure 2).

The Gompertz function is used to predict the saturation level of a phenomenon under investigation by using only the previous values of a time series (Rządkowski et al., 2015). When the fitted Gompertz function works under an adjusted R-square of 0.756 (with a 95% confidence level), it is projected that the number of relevant publications on GF can increase to over 250 by the end of 2021. Impliedly, GF is gaining enough attention and interest among the academia making it a research hotspot.

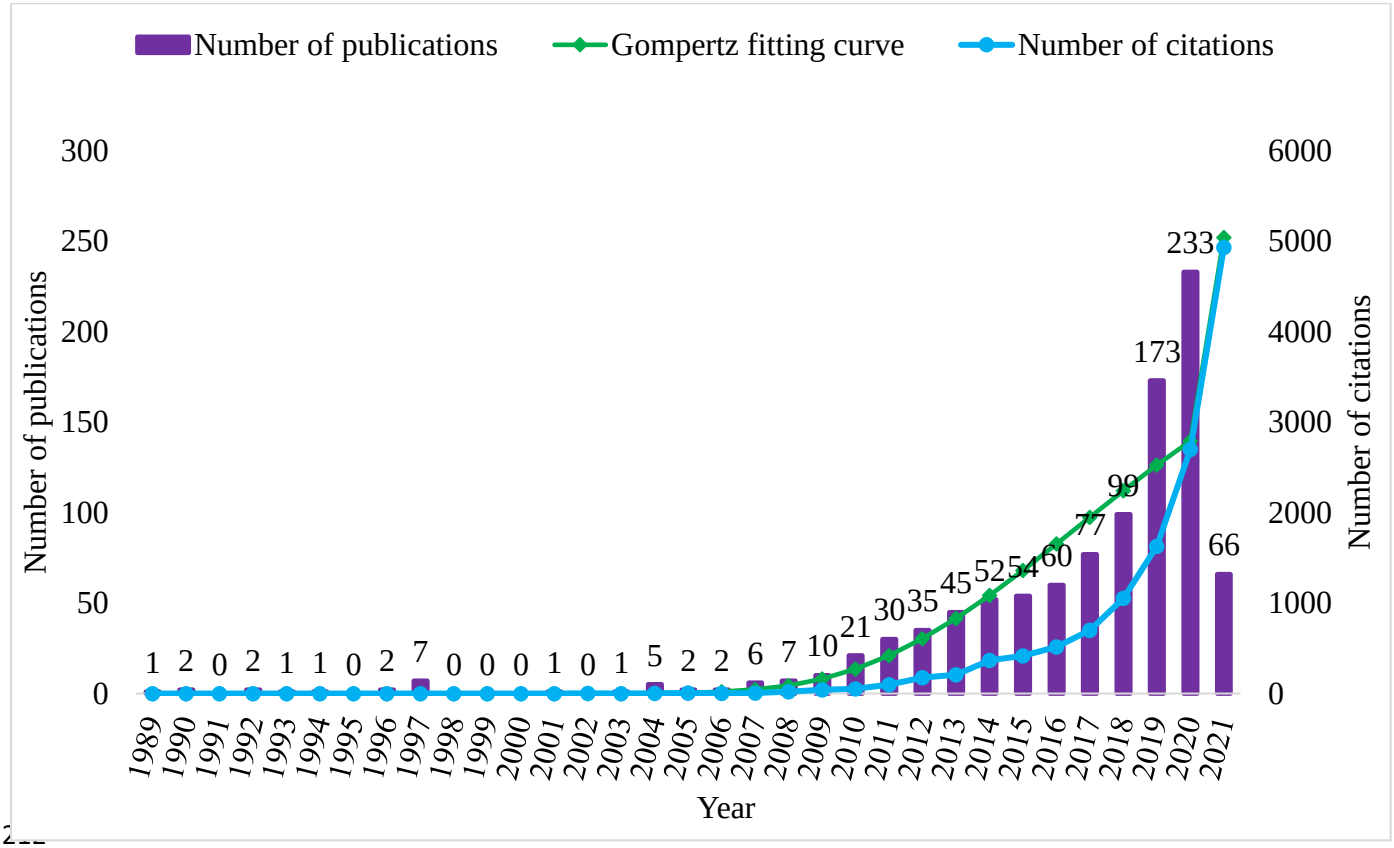


Figure 2. Trend of green finance publications from 1989 to March 2021.

3.2 Structure of GF body of knowledge

3.2.1 Main research areas: keyword co-occurrence analysis

Keywords indicate the main content of a published research and portray the scope of the research area within a domain (Su & Lee, 2010). According to Darko et al. (2019), keyword analysis aids in the identification of key areas of research. As such, the VOSviewer software was used to create a co-occurrence network of keywords. A total of 2,544 keywords were extracted from the GF dataset based on "fractional counting", of which 117 keywords met the threshold. To include a keyword in the network, we set the criterion of "minimum number of occurrences" of a keyword to "5". In using the "VOSviewer thesaurus" similar terms (e.g., SDGs or sustainable development goals) were merged (to sustainable development goals). Similar logic applies to other keywords. This criterion is based on previous studies (Debrah et al., 2022b; Hosseini et al., 2018) and several experiments to create optimal, reproducible,

controllable and understandable research clusters and network. As a result, a network of 98 nodes and 689 links was generated as shown in Figure 3, which represents the main research areas identified in GF research.

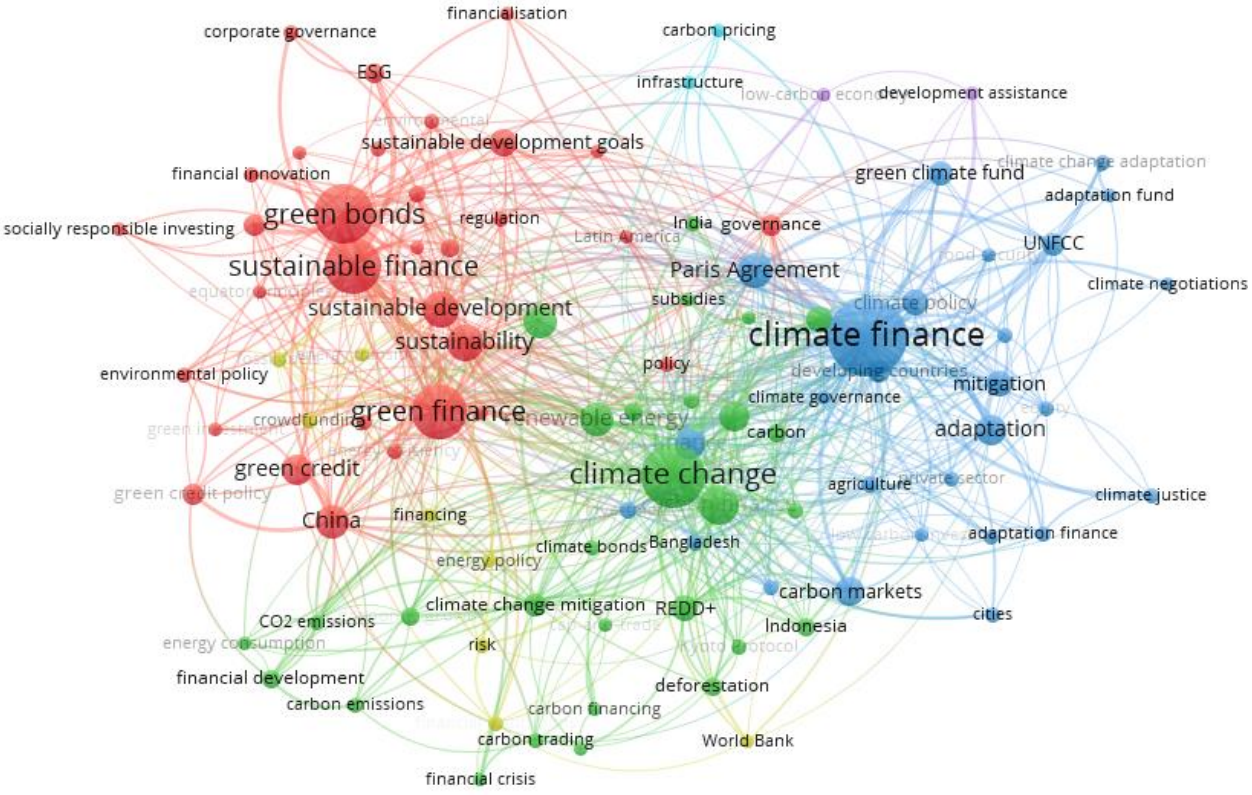


Figure 3. Main research interest in green finance research (co-occurrence network of keywords).

"Degree centrality" (Prell, 2012), the simplest and most reliable approach to calculating the network of measures led to the extraction of key information from the network. Calculating the importance based on the number of links indicates the influence of a node to other nodes. The VOSviewer co-occurrence network of keywords (Figure 3) was subsequently submitted to the Gephi software for calculating the centrality nodes. The main research areas were ranked according to the values of the degree centrality. If two or more research areas have the same degree centrality value, the area with the highest value of the *weighted degree* get the higher

ranking. A modified version of degree centrality, weighted degree centrality, considers the average of the sum of link weights across all nodes in the graph. Moreover, the *betweenness centrality* was used where the two criteria above have the same values. The betweenness centrality evaluates how nodes appear on the shortest paths between nodes in a network to identify the influential nodes (Bastian et al., 2009).

Table 2 shows relative influence of the keywords in Figure 3 based on degree centrality. The rankings and relationships of research interests highlight several relevant findings and research gaps in the GF literature.

Table 2. Relative influence of existing research interest in green finance research areas

Research areas	Degree centrality	Weighted degree centrality	Betweenness centrality	Relative influence
Climate change	66	96	469.18	1
Climate finance	65	135	457.85	2
Green finance	44	52	485.11	3
Sustainability	37	33	30.24	4
Green bonds	36	51	350.64	5
Sustainable finance	35	56	0.00	6
Renewable energy	34	28	117.11	7
Carbon finance	30	29	40.86	8
Sustainable development	30	29	21.92	9
China	29	28	123.64	10
Finance	27	21	139.97	11
Paris agreement	26	27	93.46	12
Adaptation	25	26	0.00	13
Mitigation	24	19	126.76	14
Sustainable development goals	21	16	1.98	15
Development	19	17	54.51	16
REDD+	19	16	2.52	17
Governance	19	12	71.27	18
Clean development mechanism	18	18	53.21	19
Climate change mitigation	18	12	91.21	20
Developing countries	18	12	66.55	21
Carbon markets	17	16	8.64	22
Climate policy	16	18	29.84	23
Agriculture	16	8	10.61	24
Environmental finance	15	13	54.61	25
Investment	15	7	29.19	26
Regulation	15	6	1.45	27
Green climate fund	14	14	42.73	28
Economic growth	14	9	45.66	29
Africa	14	9	8.62	30
Banks	14	6	18.93	31
Corporate social responsibility	13	11	3.47	32
Green economy	13	8	18.73	33
Energy efficiency	13	7	51.65	34
Nationally determined contributions	13	7	31.08	35
Private sector	13	6	14.41	36

Fossil fuels	13	6	10.15	37
Political economy	13	6	6.15	38
UNFCC	12	14	0.00	39
Subsidies	12	9	0.00	40
Indonesia	12	8	15.46	41
Carbon trading	12	6	40.53	42
European union	12	6	26.65	43
Climate governance	12	5	2.18	44
Equity	11	7	42.61	45
Institutional investors	11	7	25.37	46
CO_2 emissions	11	7	8.26	47
Low-carbon investment	11	5	69.28	48
Policy	11	6	12.17	49
Crowdfunding	11	6	4.73	50
Corporate sustainability	11	5	11.50	51
Innovation	11	5	4.62	52
Financing	11	4	28.13	53
Deforestation	10	7	4.33	54
Socially responsible investing	10	7	0.11	55
Carbon	10	6	2.93	56
Latin America	10	5	21.88	57
Equator principles	10	5	12.59	58
Energy policy	10	5	5.25	59
Food security	10	5	2.96	60
Green credit	9	10	16.26	61
Adaptation finance	9	6	4.39	62
Risk	9	6	1.33	63
Financial institutions	9	5	27.62	64
Kyoto protocol	9	5	8.13	65
Infrastructure	9	5	1.18	66
ESG	8	9	17.33	67
Financial development	8	8	6.94	68
Environmental policy	8	7	6.00	69
Bangladesh	8	5	10.69	70
Climate bonds	8	3	3.86	71
Project finance	8	3	1.58	72
Green credit policy	7	8	39.50	73
Financial innovation	7	7	8.18	74
Carbon emissions	7	6	0.00	75
Cities	7	5	2.34	76
Cookstoves	7	5	1.58	77
Cap-and-trade	7	5	0.00	78
India	7	4	3.17	79
Energy consumption	7	4	1.25	80
Energy transition	7	4	0.54	81
Public policy	7	4	0.00	82
World Bank	7	4	0.00	82
Climate justice	6	6	3.94	84
Climate change adaptation	6	6	1.11	85
Environmental	6	6	0.00	86
Environmental protection	6	5	16.98	87
Development assistance	6	5	1.83	88
Adaptation fund	6	5	0.00	89
Low-carbon economy	6	4	2.52	90
Green investment	6	4	1.86	91
Financialization	5	4	1.16	92
Carbon pricing	5	4	0.00	93
Financial crisis	4	4	5.56	94
Carbon financing	4	3	5.89	95
Carbon sequestration	4	3	4.83	96
Climate negotiations	4	3	0.00	97
Corporate governance	3	5	0.00	98

Some research interests (such as climate change, climate finance, GF, sustainability, green bonds, sustainable finance, renewable energy, carbon finance, and sustainable development)

have received considerable attention in GF research globally, while others have remained under-researched. This result is consistent with earlier findings of Akomea-Frimpong et al. (2021) and Zhang et al. (2019). The co-occurrence of GF, climate finance, carbon finance and sustainable finance confirms their overlapping and relatedness in financing climate change actions and sustainable development. This further indicates the consensual interests among policy makers and the academia on investigating GF efforts in line with the UN-SDGs and the Paris Agreement goals. Renewable energy (Ji & Zhang, 2019) was also seen to highly co-occur with GF showing increasing attention in GF for supporting renewable and clean energy developments.

Surprisingly, certain key research areas which appear under-researched and isolated include corporate governance, climate negotiations, carbon sequestrations, and financial crisis. This however presents promising grounds to further the course of GF especially in corporate governance since governance plays a major role in GF (Zhang et al., 2019). Other GF governance-related studies such as climate negotiations will complement existing studies. Ji and Zhang (2019) emphasised that the development of GF is heavily reliant on policy making and authorities. Even so, the presence of China among the top 10 research areas in GF reaffirms their role as a key player of GF (Zhang et al., 2019).

3.2.2 Co-occurring subject category network

"Categories" on the interface of CiteSpace were selected as the network nodes for the analysis of "subject category". We used the "minimum spanning trees to pruning" and the "time scaling" value was set to "1" to generate a co-occurring network map. Since each article indexed in Web of Science belongs to one or more subject categories, the CiteSpace network of subject categories (Figure 4) reveals the relationship between the identified categories. The category map consists of 69 nodes and 220 links. Figure 4 visualizes the top 30 GF subject categories which is ranked in Table 3. It can be seen that "Environmental Science & Ecology"

was the key subject category of GF research contributing "321 studies", followed by "Business & Economics", "Environmental Sciences", and "Environmental Studies", contributing 265, 219, and 216 studies respectively. This confirms that GF is interdisciplinary in nature (Zhang et al., 2019) with studies focusing on multiple research areas such as business and economics, accounting, finance and investment, and energy, environment and climate issues. Section 4.4 provides a detailed analysis of the dimensions or application areas in GF research so-far.

Table 3. The top-30 subject categories according to frequency (Figure 4).

No.	Frequency	Category
1	321	Environmental Sciences & Ecology
2	265	Business & Economics
3	219	Environmental Sciences
4	216	Environmental Studies
5	184	Science & Technology – Other Topics
6	170	Green & Sustainable Science & Technology
7	128	Business, Finance
8	113	Economics
9	43	Government & Law
10	40	Public Administration
11	36	Engineering
12	35	Energy & Fuels
13	31	Management
14	28	Development Studies
15	27	Law
16	27	International Relations
17	26	Business
18	23	Meteorology & Atmospheric Sciences
19	22	Political Science
20	22	Mathematics
21	20	Engineering, Environmental
22	16	Mathematics, Interdisciplinary Applications
23	16	Ecology
24	14	Multidisciplinary Sciences
25	12	Geography
26	11	Forestry
27	10	Regional & Urban Planning
28	10	Computer Science
29	10	Public, Environmental & Occupational Health
30	9	Social Sciences – Other Topics

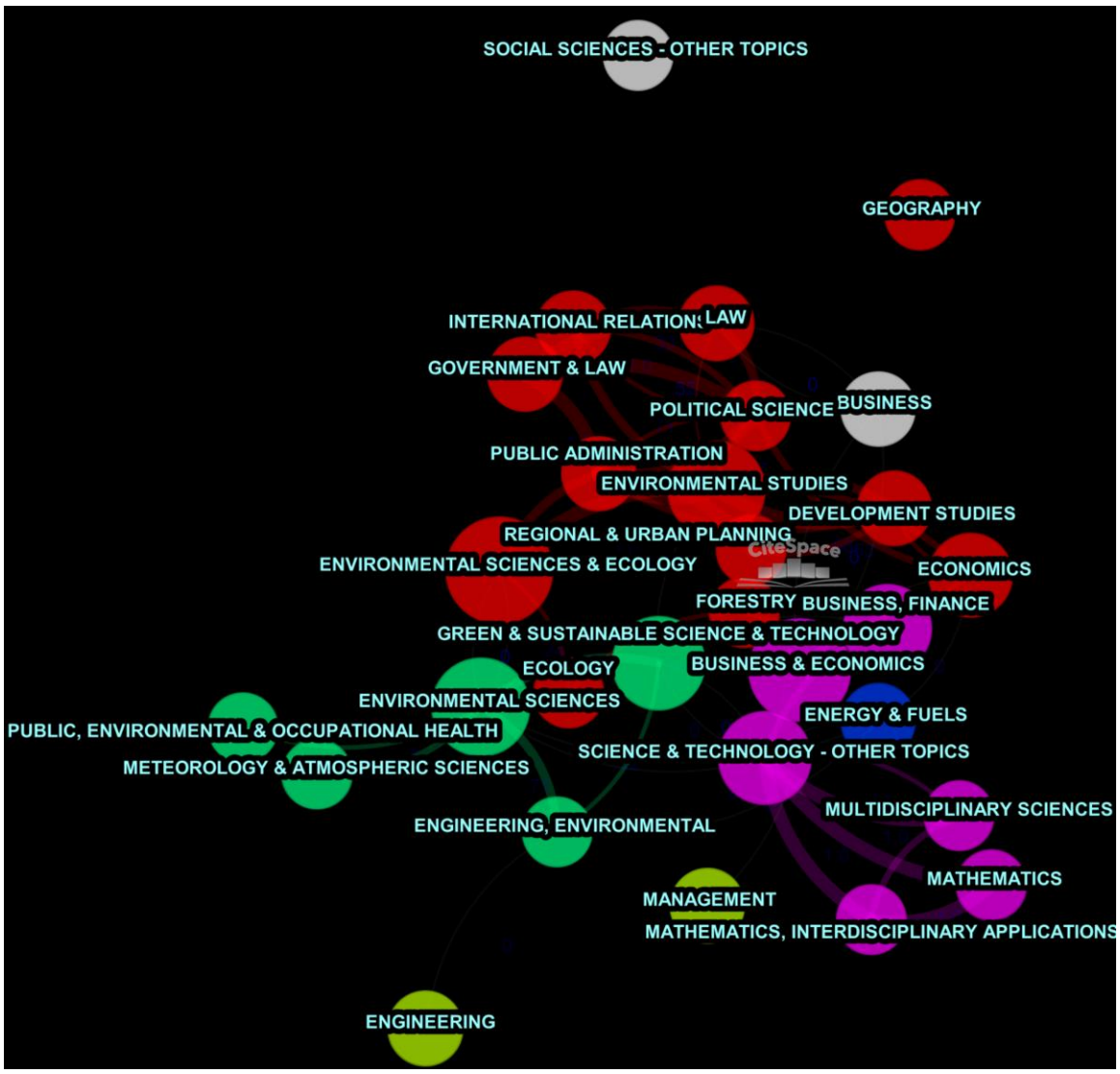


Figure 4. Co-occurrence subject category network.

3.2.3 Citation patterns: document co-citation analysis

Citation patterns between publications help to appreciate the structure of the field knowledge (Hosseini et al., 2018). According to Chen (2006), CiteSpace's clustering function provides a means to accurately identify clusters. CiteSpace is used to create a network of document co-citation clusters. Filtering minor clusters produced a network of eight major clusters (with cluster IDs #1, #2, etc.), as shown in Figure 5. Each cluster represents an underlying theme of research or topic (Darko et al., 2020; Debrah et al., 2022b). CiteSpace automatically selects a label for each cluster group using noun phrases extracted from the titles, keyword lists, and abstracts of publications to describe the nature of each defined cluster. In this type of analysis,

the structure of the clusters is the focus as against the content (Chen, 2006). The log-likelihood ratio (LLR) algorithm (Chen, 2014) was implemented to generate the cluster labels in Figure 5.

Along with the cluster visualization, the CiteSpace has the function to assess the "structural properties" of the whole network through the calculation of two basic metrics, the modularity Q-value range and the mean silhouette value. Ranging from 0 to 1, the modularity Q reflects the relationships and connections among the clusters. A modularity Q value of 0.6507 (~ 0.7) is acceptable and quite high (Liang et al., 2018; Chen, 2014). This indicates that the division capacity of the network into clusters is strong with fairly dense links between nodes in clusters, but sparse links between nodes of different clusters. In addition, the silhouette value of each cluster indicates which nodes fit well into the cluster as well as which nodes lie somewhere between the clusters. A mean silhouette value close to 1 indicates that references within a cluster contain highly consistent or similar content (Liang et al., 2018; Chen, 2014). The mean silhouette value of 0.8855 indicates a high homogeneity with similar or consistent content. These findings imply that while few studies have been conducted on GF, the available studies embody a network with dense connection that addresses similar issues in the research area. However, it can be concluded that quite dense nature of the clusters indicates that the study areas although similar are quite disjointed. The silhouette values calculated indicates an almost homogeneous GF research. Hosseini et al. (2018) argue that such homogeneity in clustering occurs when authors fail to cite studies outside their clusters. As a result, the network's clusters are connected through citations internally rather than outside of their clusters. Consequently, it can be deduced that GF research appears to be inward, not benefitting from borrowing theories/ideas applicable to other research fields or outside of their cluster.

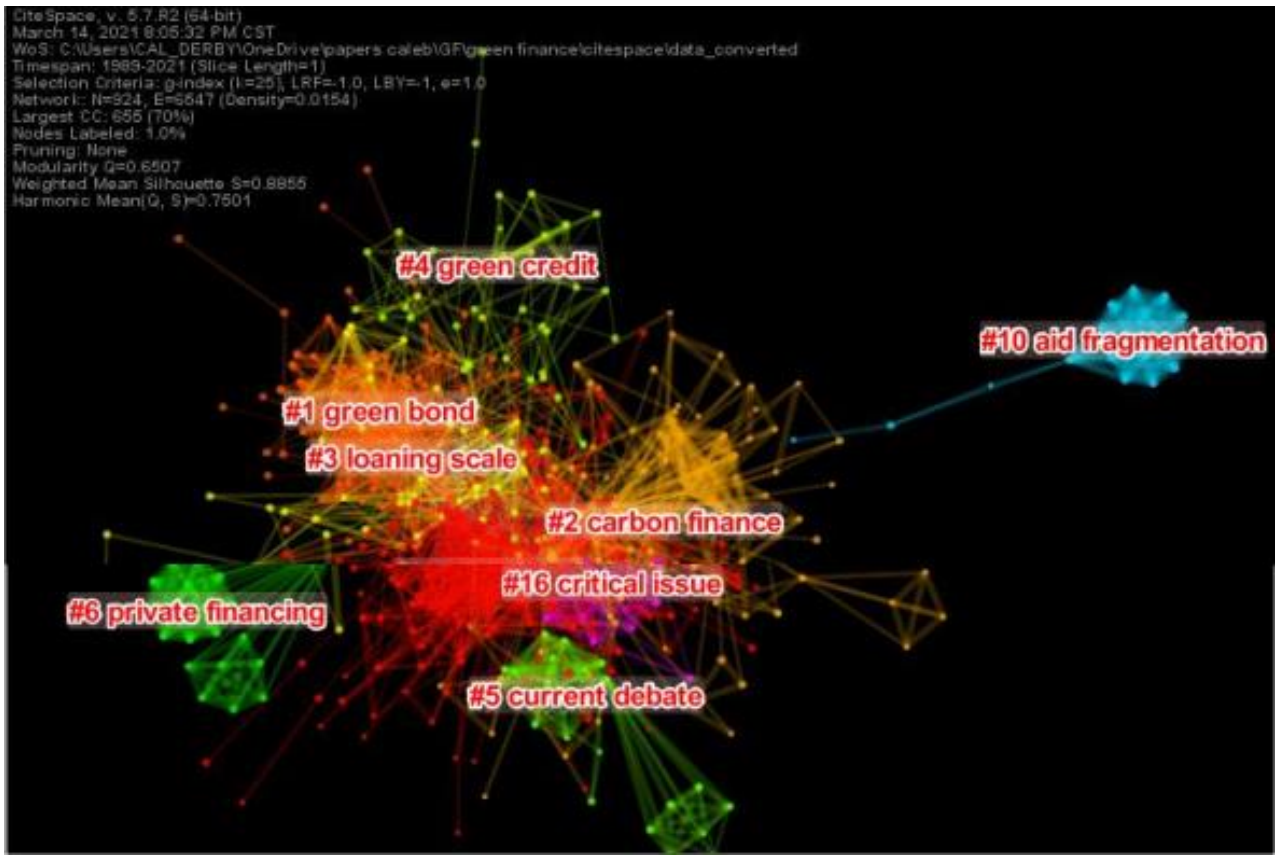


Figure 5. Clustering structure for green finance research.

The current body of knowledge on GF comprises eight major clusters as shown in Table 4. With the calculated silhouette values, all approaching homogeneity, confirm the earlier assertion that GF research appears to be introspective, and does not benefit from borrowing applied theories/ideas from other research fields. The mean (year) indicates the average length of time during which a given cluster has been researched. Table 4 shows that GF research has been dominant within the 21st century (2001-2014) except cluster #6 which was averagely researched within 1998. Additionally, the following observations were made. The largest cluster (#1) has 122 members, a silhouette value of 0.861 and is labelled as "green bond" by the LLR. The second largest cluster (#2) has 119 members, a silhouette value of 0.890 and is labelled as "carbon finance". This suggests the dominance of "green bonds" and "climate finance" – typologies of GF (Debrah et al., 2022a) – in the research space.

342 **Table 4.** Citation patterns and identified clusters (Figure 5).

Cluster ID	Size	Silhouette value	Mean (Year)[a]	Focus of the cluster
#1	122	0.861	2014	Green bond
#2	119	0.890	2005	Carbon finance
#3	59	0.878	2014	Loaning scale
#4	41	0.947	2008	Green credit
#5	25	0.993	2009	Current debate
#6	20	0.999	1998	Private financing
#10	18	0.994	2001	Aid fragmentation
#16	12	0.991	2010	Critical issues

343 [a] Note: This shows the average year of publication

344

345 *3.2.4 Burst detection*

346 Citation burst detection is associated with keywords with high frequency of occurrence in a
347 specific time period, i.e., fast-growing topics, or topics associated with the highest citations
348 (Chen, 2014). A citation burst analysis was performed using CiteSpace. 28 keywords
349 experienced citation bursts from the dataset. Figure 6 shows the top 25 keywords with the
350 highest citation burst. The light green lines in the figure represent the year range of reviewed
351 literature, while the red line stands for the duration of a citation burst event.

352 Figure 6 shows that green bond (burst strength, 17.31; burst period, 2020-2021), carbon
353 finance (9.13; 2008-2015), clean development mechanism (8.91; 2003-2015), finance (8.24;
354 2016-2018), and green finance (8.10; 2019-2021) were the five keywords with the strongest
355 burst amongst the 25 keywords. Regardless, the low burst strength of the other keywords
356 varying from 4.02 to 7.50 reinforces the need for more GF research. Additionally, the burst
357 periods (2019-2021) of major GF keywords (such as “green bond”, “green finance”, “green
358 credit”, “sustainable finance”) and “sustainable development goal” suggest the recent interest
359 in related research.

360

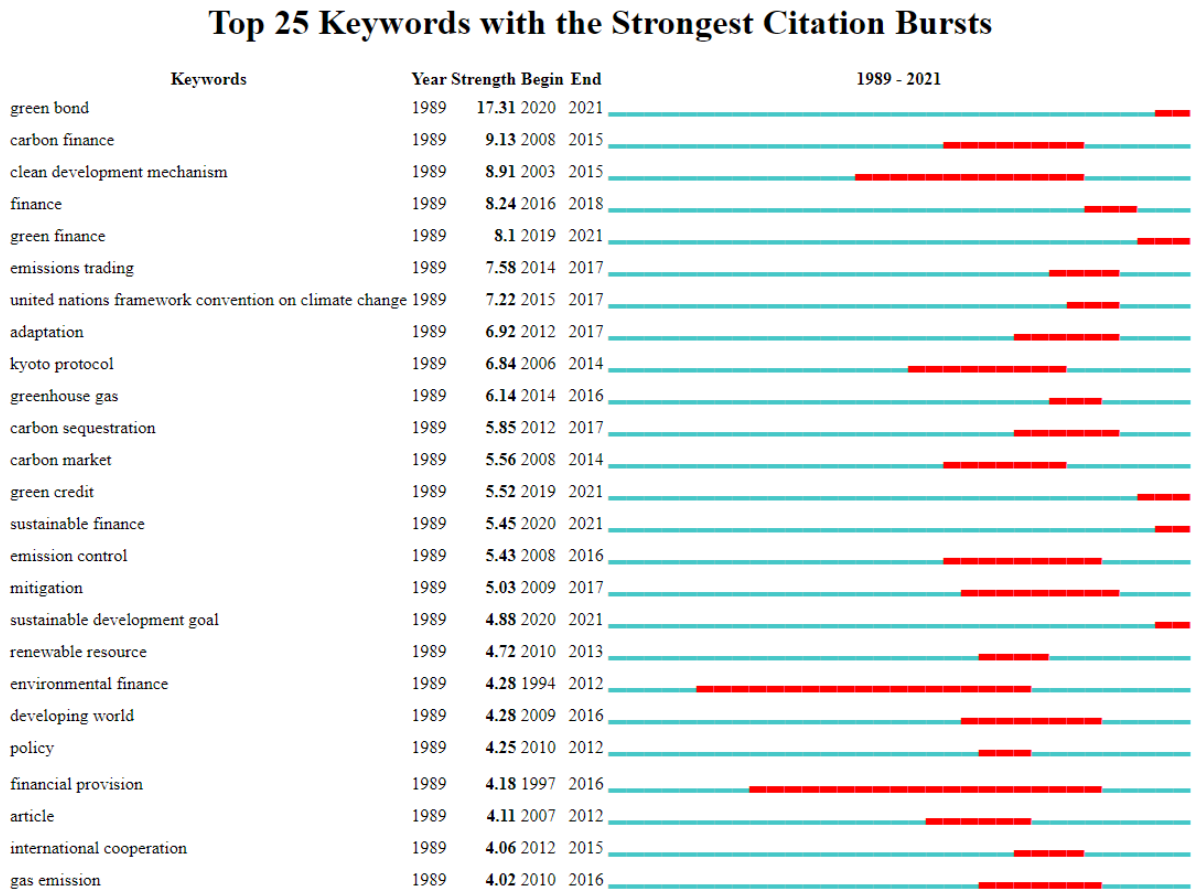


Figure 6. Top 25 keywords with the strongest citation burst in green finance literature (1989-2021)

3.2.5 Citation and distribution analysis toward significant articles

Citation information for the 995 documents was analyzed to reveal the top 15 most cited publications in the field of GF as shown in Table 5 below. Knowledge of the most-cited GF publications informs researchers and practitioners on key information sources. The citation count for GF research is encouraging baring the few available studies. As shown in Table 5, all the most cited GF publications were conducted in the 21st century, an indication of the nascency and current widespread growth of the research area.

Table 5. Top 15 most cited green finance-related publications

S/N	Authors	Title	Citations		
			Scopus	Web of Science	Google Scholar

1	Schueth (2003)	Socially responsible investing in the United States	220	162	671
2	Campiglio (2016)	Beyond carbon pricing: The role of banking and monetary policy in financing the transition to a low-carbon economy	160	149	385
3	Ebeling & Yasue (2008)	Generating carbon finance through avoided deforestation and its potential to create climatic, conservation and human development benefits	156	134	321
4	Ziegler et al. (2012)	Carbon outcomes of major land-cover transitions in SE Asia: Great uncertainties and REDD+ policy implications	129	122	201
5	Robiou et al. (2017)	Equitable mitigation to achieve the Paris Agreement goals	122	93	206
6	Zerbib (2019)	The effect of pro-environmental preferences on bond prices: Evidence from green bonds	116	110	320
7	Wylie et al. (2016)	Keys to successful blue carbon projects: Lessons learned from global case studies	105	103	174
8	Taghizdeh-Hesary & Yoshino (2019)	The way to induce private participation in green finance and investment	103	92	149
9	Yip & Bocken (2018)	Sustainable business model archetypes for the banking industry	103	90	204
10	Lewis (2010)	The evolving role of carbon finance in promoting renewable energy development in China	99	93	182
11	Zhang et al. (2011)	Tracking the implementation of green credit policy in China: Top-down perspective and bottom-up reform	91	87	146
12	He et al. (2019)	Green credit, renewable energy investment and green economy development: Empirical analysis based on 150 listed companies of China	82	77	99
13	Li et al. (2018)	Green loan and subsidy for promoting clean production innovation	79	78	92
14	Reboredo (2018)	Green bond and financial markets: Co-movement, diversification, and price spillover effects	78	75	153
15	Huang & Liao (2019)	Loaning scale and government subsidy for promoting green innovation	72	71	89

3.2.6 Top research outlets: outlets citation analysis

In bibliometric analysis, the analysis of direct citation from journals (outlets) in any field of study reveals the important and growing journals in the specific field (Hosseini et al., 2018). According to Darko et al. (2020) analyzing academic journals in any scientific domain is essential for readers and authors to find the best sources of information and where to best publish, and for journal editors to make relevant adjustment to their journals' goals. Institutions and libraries may also benefit in optimizing their investment in journals. Using the VOSviewer; "type of analysis" was "citation", and the "unit of analysis" was "sources". The "minimum number of documents of a source" and the "minimum number of citations" were both set to "5", to achieve optimal network. Of the 420 identified sources, 26 reached the threshold and were included in the resulting network consisting of 26 nodes and 111 edges. The weight calculation based on the number of links indicates the influence of one node on the other nodes.

The VOSviewer direct citation analysis of outlets (Figure 7) was subsequently submitted to the Gephi software for calculating the centrality nodes. Nodes and edges were resized based on their weight strengths. Table 6 ranks the top 25 GF outlets according to the values of weighted degree centrality in the network.

The results show that *Sustainability*, having obtained the highest weighted degree value (98), is the most influential GF research outlet. As indicated in Figure 7, due to citations, there is considerable information flow between *Sustainability, Journal of Cleaner Production, Energy Economics,* and *Finance Research Letters.* Similarly, *Climate and Development* and *Climate Policy*, which are among the 10 topmost journals publishing in GF, exhibited high influence in the network. Thus, these well-recognized GF outlets could be the first reference point for stakeholders.

As noted, the interdisciplinary nature of the journals publishing in GF is encouraging with journals ranging from economics, accounting, finance and investment, energy, environment and climate issues or policies. Contrastingly, it is evident that journals publishing in other top research areas like engineering and construction, social sciences, and health and medicine, among others have paid less attention to GF research. Notably, the mainstream finance and economics journals (such as *Journal of Finance* and *Journal of Financial Economics*) are also silent on GF research, although this research area has been acknowledged as the future of finance (Zhang et al., 2019). This observation is a clarion call for the introduction of GF techniques and models in other mainstream (finance, economics, construction and engineering, social sciences, and health and medicine) journals by making relevant adjustments to their goals to encourage the research community to publish more in GF which serves as a catalyst for sustainable development.

Table 6. Top 25 green finance research outlets

Outlets	Number of publications	Weighted degree value	Rank [a]
Sustainability	74	98	1

Journal of Cleaner Production	35	89	2
Climate Policy	54	80	3
Journal of Sustainable Finance and Investment	49	77	4
World Development	11	49	5
Energy Economics	13	47	6
Finance Research Letters	15	46	7
International Environmental Agreements: Politics, Law and Economics	14	34	8
Climate and Development	16	32	9
Energy Policy	19	30	10
Business Strategy and the Environment	7	25	11
Climatic Change	9	24	12
Ecological Economics	12	24	13
Technological Forecasting and Social Change	6	21	14
Global Environmental Change	8	17	15
Journal of Environment and Development	5	15	16
International Journal of Environmental Research and Public Health	6	14	17
Energy for Sustainable Development	10	11	18
Global Environmental Politics	5	11	19
Land Use Policy	8	9	20
Environmental Research Letters	9	8	21
Accounting and Finance	5	7	22
International Journal of Green Economics	5	3	23
Global Policy	6	2	24
World Economy and International Relations	7	2	25

[a] Ranking based on weighted degree values

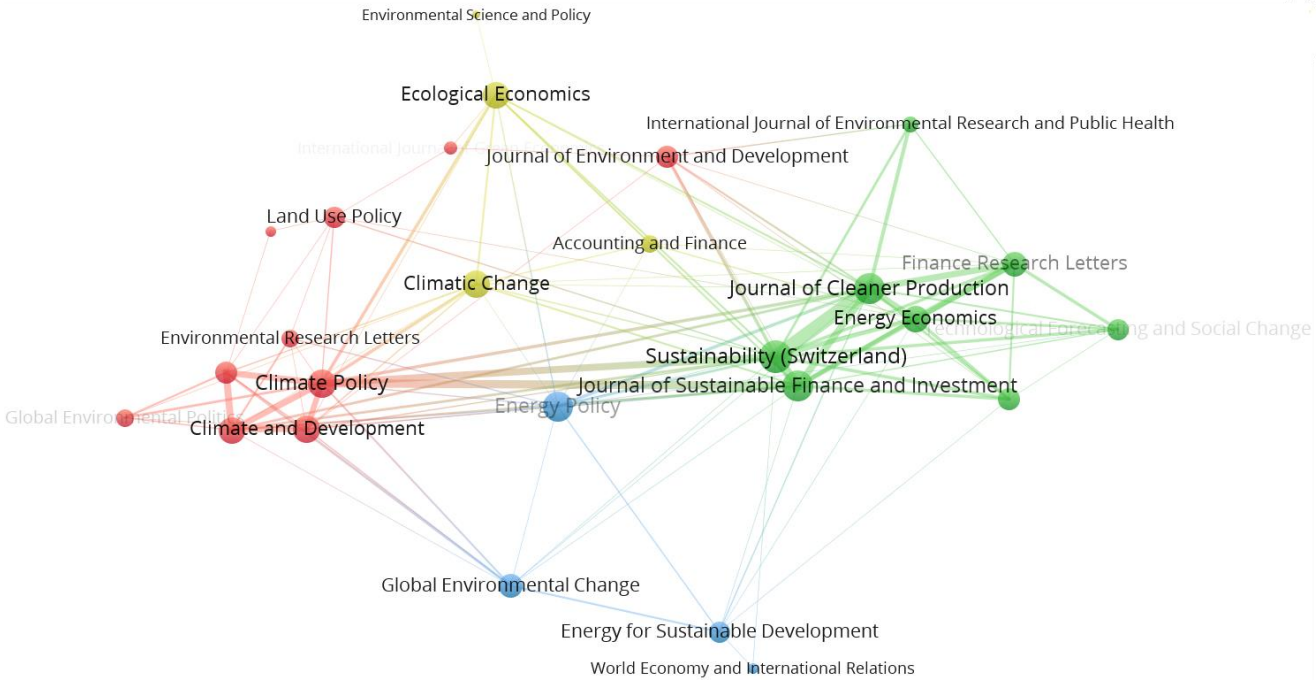


Figure 7. Network of prominent outlets for green finance research.

3.3 Scientific collaboration in GF research: co-authorship analysis

"Co-authorship" is an abbreviated form of scientific collaboration. Cognizance of the existing scientific collaboration network in any research field can expedite funding, expertise, and specialties; limit research isolation; and enhance productivity (Hosseini et al., 2018). By these standards, the co-authorship network of institutions and countries in GF literature is presented in the following sub-sections.

3.3.1 Influential institutions

Realizing the collaboration network of institutions is critical to high investments and research interest in GF, a key to lasting scholarly communication and policy-making (Debrah et al., 2022b; Ding, 2011). Using the VOSviewer, the "type of analysis" was "co-authorship", the "unit of analysis" was "organizations", and the "counting method" was "fractional counting". The "minimum number of documents of an organization" and the "minimum number of citations" were set to "2" for achieving the optimum network. The resultant network comprised 71 out of 2,057 organizations identified.

As Figure 8 portrays, there is a clear lack of cross-institution collaboration in the network, highlighting the neglected nature of the existing literature. In order to attain the highest standard of scholarship and debate on GF, institutions should collaborate to benefit from varied knowledge and research experience as this is currently lacking in GF body of knowledge. Interestingly, the network is not comprised of only universities but other purely research-based institutions (e.g., Stockholm Environment Institute) and financial institutions (e.g., Asian Development Bank) contributing to GF research.

Figure 8. Collaboration network of institutions in the literature on green finance

3.3.2 Influential countries

We have created a VOSviewer network to identify the most influential countries and to show the collaborations between them. This showed the countries that were keen on GF research. The "type of analysis" was "co-authorship", the "unit of analysis" was "countries", and the "counting method" was "fractional counting". The "minimum number of documents of an organization" and the "minimum number of citations" were set to "10" to achieve an optimal network. Of the 110 countries identified, 27 met the threshold and were included in the resulting network. The VOSviewer citation analysis of countries (Figure 9) was subsequently submitted to the Gephi software for calculating the centrality nodes. Table 7 ranks the top 25 countries keen on GF research based on the values of the weighted degree centrality in the network. The network comprised 27 nodes and 187 edges. Nodes and edges were resized based on their weight strengths. Key highlights revealed by the network are described below.

The US, UK, and China were found to be the most influential countries in this GF collaboration network, with US emerging as the biggest contributor to the field. This is consistent with a recent study by Zhang et al. (2019) where the authors claimed that the dominance of US in GF research can be attributed to international world bodies like the World Bank and the UN among others which are headquartered in US and as such can much facilitate and encourage relevant research. The dominance of Europe in the network can be attributed to the EU's policy against climate change – the European Union Emission Trading System (European Commission, 2016) – which has attracted a substantial attention from academic researchers. On the other hand, the network showed that a few developing countries (China, India, South Africa, Vietnam, Malaysia, Kenya) have been contributing to GF research – hence the need for developing countries to improve upon their current contribution to GF research and development.

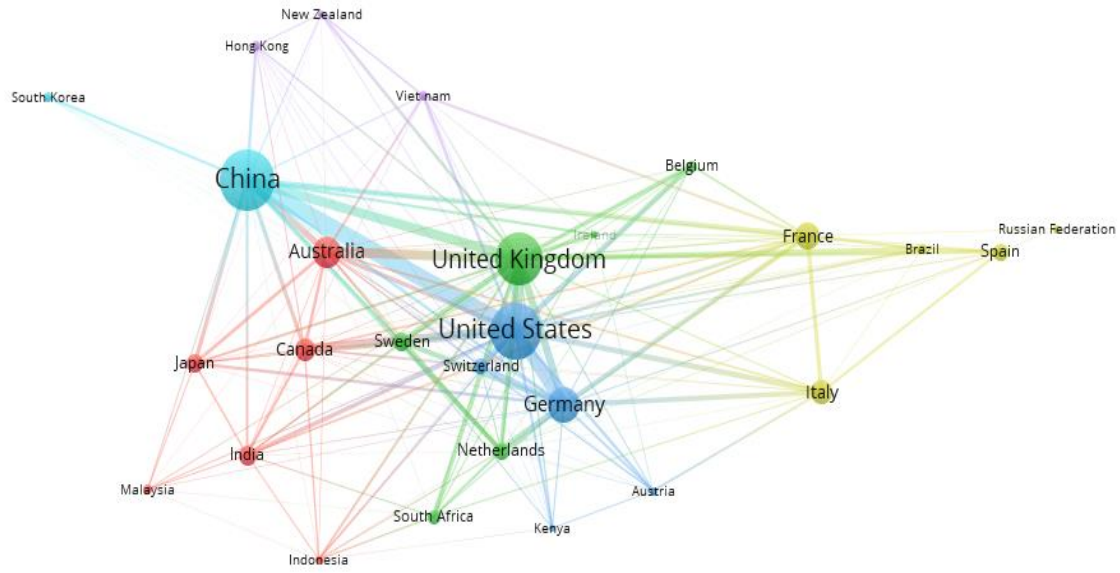


Figure 9. Collaboration network of countries in the literature on green finance.

It is obvious from the network that the collaboration link between researchers in US-China is stronger than US-UK. In terms of relationships, the strongest ties were between the paired countries: US-China, US-Germany, China-UK, US-UK, and UK-Australia. Compared to the

187 relations, these existing five strong collaborations identified are very limited and does not represent the importance of the area. It can be concluded that there is limited cross-border collaboration and comparative studies in the GF literature. Generally, while strong collaborations existed between the developed countries, weaker nodes and links indicating little collaboration were found for many developing countries. This highlights the need for national institutions to reform policies and develop more collaboration with each other to advance GF research in terms of global collaboration, knowledge exchange, and enhanced productivity in the research area.

Table 7. Top 25 collaborating countries in green finance research

Countries	Number of publications	Number of citations	Degree value	Weighted degree value	Rank [a]
United States	176	2215	24	80	1
United Kingdom	157	2109	25	70	2
China	192	1195	20	56	3
Germany	93	887	22	51	4
Australia	76	832	23	33	5
France	60	618	17	28	6
Netherlands	34	503	19	26	7
Canada	48	871	16	25	8
Sweden	37	557	16	23	9
Switzerland	30	660	19	20	10
Italy	51	433	12	20	11
India	42	368	15	18	12
Japan	35	309	14	16	13
South Africa	25	270	11	13	14
Belgium	20	136	9	13	15
Brazil	17	145	10	12	16
Austria	14	265	12	11	17
Spain	34	195	9	11	18
Vietnam	16	90	11	11	19
Indonesia	14	156	12	10	20
Ireland	11	121	12	10	21
Kenya	11	153	10	8	22
Hong Kong	15	190	9	8	23
New Zealand	11	83	9	7	24
Malaysia	15	45	9	6	25

[a] Ranking based on weighted degree values

4. Systematic analysis

To provide an in-depth analysis of GF research, this section presents a systematic analysis of carefully selected studies. In using the pre-defined criteria (see Figure 1), a qualitative screening and examination of GF publications identified in stage 4 revealed 60 relevant

publications included in the systematic analysis (Appendix A). The sub-sections first argue the theoretical underpinning promoting ecological balance between conventional finance and addressing the climate change through GF (sub-section 4.1). Subsequently, we describe a content analysis of the methodological characteristics (sub-section 4.2), underlying key areas (sub-section 4.3), and the application areas of the reviewed studies (sub-section 4.4).

4.1 Theoretical underpinnings of GF

As noted, GF supports low-carbon investments that reduce GHG emissions compared with counterfactual conventional finance. This is necessary to promote ecological balance between conventional finance and preserving the environment to address climate change. However, with no consensus achieved on its definition (Zhang et al., 2019), researchers and practitioners are still debating on the theoretical basis for GF. At present, the question of whether GF is underpinned by existing or new finance theories is one of the central dilemmas among stakeholders.

Conventional finance is rooted in "neoclassical economic theory" (UNEP, 2015) and "efficient market hypothesis" (Fama, 1970). The theories explain that finance or capital markets are *rationally* "driven by profit opportunities" towards maximizing shareholder wealth. However, the assumption that *many* investors are able to incorporate *all available information* to make rational decisions in profit-driven (low-carbon) investments have been challenged in the literature (Ameli et al., 2020). This refers to "bounded rationality" (Simon, 1990). Besides, the complexities associated with sustainability cannot be explained by a single theory (Grubb et al., 2015) due to resource, cost and economic trade-offs. In line, Grubb et al. (2014) proposed three basic domains for GF: (1) "behavioral and organizational economics" that assumes that the organizational decision-making diverges from the traditional assumption of rational choice theory; (2) "neoclassical and welfare economics" that is premised on the basic rational economic actors and market efficiency; and (3) evolutionary and institutional

economics that explores evolving structural and institutional effects on economic systems. Hall et al. (2017) argue that since the neoclassical and behavioral finance assumptions of capital markets fail to consider wider systemic changes relating to Grubb et al. (2014)'s "third domain", they are inadequate to facilitate GF transformations. Extending this, Hall et al. (2017), propose "adaptive markets hypothesis" which considers structural and behavioral constraints on investments and associated long-term systems change as more suitable. The adaptive market hypothesis is grounded in *evolutionary economics theory* (Nelson & Winter, 1985). This theory incorporates long-term and progressive change in economic or "profit-seeking" decisions. The literature suggests that investment environment and investor behavior evolve over time by considering the realities of the period (Lo, 2012) – *climate change* in this case. Hence, institutionally focused understanding about evolutionary systems of GF is necessary. Additionally, Foxon (2011) proposes a *coevolutionary framework* to underpin sustainability transition by combining *ecological economics* with evolutionary economics and other ideas from socio-technical transitions, innovation systems and industrial dynamics. Ecological finance theory proposes re-embedding financial systems with social and ecological constraints to ensure social resilience (Lagoarde-Segot & Martínez, 2021).

From the above, the evolutionary economics and ecological finance theories largely underpin current GF research. For instance, relying on "adaptive market hypothesis", Kawabata (2019) examined how *institutional and stakeholder theories* are effective in promoting GF. The study found that external institutional pressures and internal corporate governance are critical to GF mobilization. Additionally, Zerbib (2019) and Lau et al. (2022) agree that GF growth represent a combination of non-pecuniary environmental benefits, as perceived by the investor, as well as a range of monetary and non-monetary benefits associated with GF. Flammer (2021) indicate that companies use GF to credibly signal their commitment toward the environment. From the above, it is observed that unlike conventional finance, GF considers other non-monetary benefits such as environmental benefits. Despite the increasing

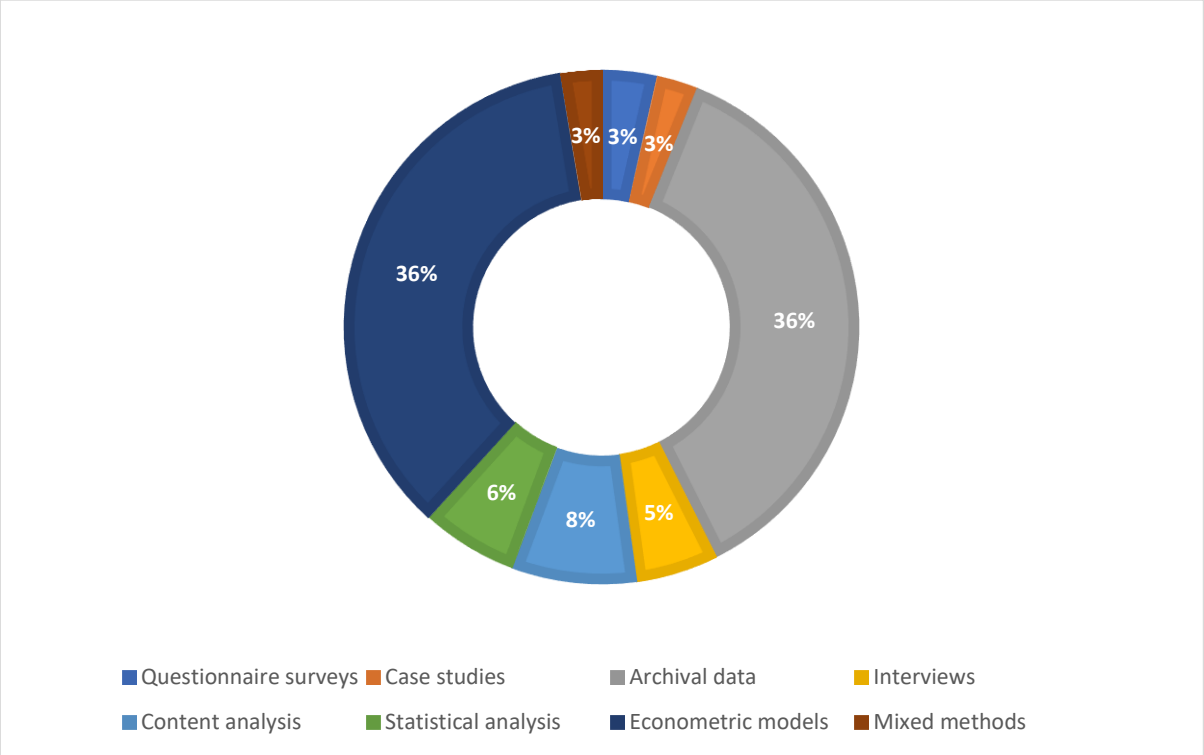
debate on the theoretical frameworks supporting GF, more research is necessary to build consensus on these theories. This is critical to streamline what can be classified as "green" in financing, and the pecuniary and non-pecuniary benefits of GF. Additionally, future empirical studies should discuss how their results aligns with existing GF theories. This necessary to relate and interact with the results in more "knowledgeable and competent ways" than would otherwise be the case (Lawson, 2019 p.3).

4.2 Methodological characteristics of reviewed studies

From the reviewed papers, several data collection methods and data analysis methods were employed in existing GF studies. Archival or historical data was the most preferred (36%) data collection method in past studies. Archival data sources were predominantly the Bloomberg Green Bond Index, Barclays MSCI Green Bond Index, S&P Dow Jones Green Bond Index, Solactive Green Bond Index, Bank of America Merill Lynch Green Bond Index, NASDAQ OMX Green Economy stock, Environmental Finance, and Xinhua GF database. Others were the Thomas Reuters Datastream, WilderHill Clean Energy Index, RENIXX world index, Wind database, China Statistical Yearbooks, UNFCCC Nationally Determined Contributions (NDC) registry, and the Climate Bonds Initiative (CBI) database. Other data collection methods such as interviews (5%), questionnaire surveys (3%), and case studies (3%) have not seen widespread use in GF research so far.

The primary and secondary data in past studies were analyzed using robust tools such as content analysis, statistical models, econometric models, and mixed methods. From the reviewed studies, while econometric analysis was most-preferred (accounting for 36%); statistical models, content analysis, and mixed-methods were least preferred (accounting for 3% each). The content analysis was performed on GF policy reports and interviews. Regarding the surveys, the respondents ranged from professionals in building and construction, banking and finance, private investors, asset-managers and asset-owners, actuaries, and scholars in the

568 academia. The statistical models employed in past studies included system dynamics, relative
569 importance index, mean score analysis, sample t-test, analysis of variance, multiple regression
570 analysis, factor analysis, and structural equation modelling. Econometric models employed
571 included ordinary least squares regression analysis, fixed effects generalized least squares,
572 propensity score matching method, difference-in-differences, cross-quantilogram method,
573 Diebold-Yilmaz approach, Barunik-Krehlik method, wavelet-based methods, spatial
574 autocorrelation test, vector autoregressive model, quantile regression models, asymmetric
575 multifractional analysis, and generalized method of moments. Notwithstanding, some studies
576 employed mixed-methods analysis. The findings appear consistent with Akomea-Frimpong et
577 al. (2021) who agree that GF require robust empirical evidence. Figure 10 presents a summary
578 of the research methodologies employed in past studies.
579



580

581 **Figure 10.** Research methodology adopted in green finance research.

582

583 *4.3 Key areas of GF*

Following a comprehensive review of the 60 selected publications, this section provides a content analysis of the key areas of GF. We classify GF research into six key areas or research hotspots. More significantly, the research hotspots are highly related to the cluster analysis (Figure 5). For instance, (1) "green bond market and greenium" is related to "green bond (#1) and private financing (#6)"; (2) "green credit (loan)" is related to "green credit (#4)"; (3) "carbon investment and market" is related to "carbon finance (#2)"; (4) "green banking" is related to "loaning scale (#3)"; (5) "market stress and GF" is related to "current debate (#5) and critical issue (#16)"; and (6) "domestic and international climate finance policies" is related "aid fragmentation (#10)"; details of which are discussed next.

4.3.1. Green bond market and 'greenium'

A green bond is "any type of bond instrument where the proceeds are exclusively applied to finance or re-finance projects with clear environmental benefits". Eligible green projects include energy efficiency; renewable energy; terrestrial and aquatic biodiversity conservation; climate change adaptation; sustainable water and wastewater management; pollution prevention and control; clean transportation; circular economy adapted products, production technologies and processes; and/or green buildings (ICMA, 2018). Since the inception in 2007, the green bond market has risen from US$1.5 billion to US$1.524 trillion (2021) (CBI, 2021). This momentous market growth is accompanied by a growing literature examining the outcomes of green bonds in different sectors such as green building (MacAskill et al., 2021), clean or renewable energy (Kuang, 2021; Rannou et al., 2021; Reboredo, 2018), and others. The green bond market growth is influenced by factors such as credit ratings (Chiesa & Barua, 2019; Mankata et al., 2020), coupon rate, collateral availability, issuer's sector and financial health (Chiesa & Barua, 2019), investor attention (Owusu-Manu et al., 2021; Pham & Luu Duc Huynh, 2020), sustainable leadership by government and financial institutions, issuer-investor collaboration (Torvanger et al., 2021), NDCs, macroeconomic factors (e.g., GDP, lower

interest rates), and institutional factors (e.g., regulatory quality) (Owusu-Manu et al., 2021; Tolliver et al., 2020). Other studies reveal that green bonds deliver the most effective diversification (Kuang, 2021; Naeem et al., 2021; Reboredo, 2018) and hedging benefits (Naeem et al., 2021; Rannou et al., 2021) for diversified portfolios. Alongside, evidence from both price connectedness (Ferrer et al., 2021) and time-frequency connectedness analysis (Pham, 2021; Reboredo et al., 2020; Reboredo & Ugolini, 2020) show that green bonds are almost identical to bonds in other high-quality financial markets such as government and corporate bonds.

Recent literature has therefore focused on investigating the evidence of a *greenium* (or green premium) in the green bond market. A greenium is the yield premium or discount on green bonds vis-à-vis similar conventional bonds (Hyun et al., 2020). It is observed that the literature remains inconclusive on the extent of a greenium in the green bond market. This is because while some studies report a greenium ranging from -2 to -22 basis points (Hyun et al., 2020; Sheng et al., 2021; Zerbib, 2019), others observe no significant yield premium (Hyun et al., 2020; Larcker & Watts, 2020). The mixed evidence in the literature could be attributed to the risk of greenwashing (Lau et al., 2022) or methodological design misspecifications (Larcker & Watts, 2020) that lead to inconsistent results. However, analogous to MacAskill et al. (2021), averagely, a greenium is reported in both primary and secondary market studies reviewed. The greenium enjoyed by green bonds increases with certifications (e.g., the CBI certification) (Hyun et al., 2020). Based on the literature, green bonds appear as a valuable tool to fight climate change without sacrificing returns (Ferrer et al., 2021). The green bond market therefore represents an emerging, promising, and impactful financing mechanism in climate change mitigation efforts (MacAskill et al., 2021) with potential for growth. More so, further research and consensus are needed on the extent of a greenium to promote increased green bond investment.

636 *4.3.2 Green credit (loan)*

637 Green credit or loan basically refers to the "green deposit and loan industry, including mortgage
638 loans and project loans" (Ren et al., 2020) that aims to facilitate and support environmentally
639 sustainable economic activity (Loan Market Association, 2021). To facilitate the growth of
640 GF, a mandatory guideline, the green credit policy, was introduced by the Chinese government
641 which has been the focus of majority of academic studies on green credit in GF. This policy
642 requires "banks to allocate more investment toward green industries, constrain investment in
643 pollution and overcapacity industries, and withdraw financing from prohibited industries that
644 have been primarily targeted for their negative environmental impact" (China Banking
645 Regulatory Commission, 2012). For example, the results of Hu et al. (2021) showed that the
646 green credit policy have had a positive and significant effect on the green patent output of
647 heavily polluting enterprises, especially those with stronger financial constraints. Similarly,
648 Song et al. (2021) proved that green credit, credit scale, environmental regulations,
649 technological progress, and industrial structure have significant effect on high-efficiency
650 utilization of energy. He et al. (2019) agree that combining the green credit policy of
651 government and financial institutions is necessary to maximize the promoting effect of
652 renewable energy investment on green economy. Further, Chen & Chen (2021) suggest that
653 commercial banks should increase the proportion of green credit, gradually tighten the funds
654 flowing to high emissions, and increase the investment in credit funds for environmental
655 protection and green industries. Other studies have focused on green loan and government
656 subsidy (Li et al., 2018), causal effects of bank loans on firms' pollution abatement
657 performance (Zhang et al., 2021), and the impact of higher green credit ratio on reducing a
658 bank's non-performing loan ratio (Cui et al., 2018). Despite the growing studies on green credit
659 implementation, various limitations have been identified. For example, the low implementation
660 of green credit policy (Zhang et al., 2011) could be attributed to environmental tax regulation
661 (Liu & He, 2021). Based on the findings from the reviewed studies, the literature has focused

on strengths and limitation of the green credit policy implementation in China. The findings could therefore serve as useful lessons for other countries to develop their own green credit policy suitable to their local condition. This is necessary to explore available green credit policy incentives to promote GF in both private and public sectors.

4.3.3 Carbon investments and markets

Carbon finance or investment refers to "trading and investment activities relating to financial policies for reducing GHG emissions such as trading and investment of 'carbon emission rights', and their derivatives, as well as financing low-carbon projects and related activities". Carbon market is a place for these financial transactions, including arrangements and policy systems (Zhou & Li, 2019). Carbon credits are verified by a certain "standard", which includes accounting, monitoring, verification, and certification standards, and registration and enforcements (Wylie et al., 2016). Two types of carbon market exist: the *regulatory compliance* and *voluntary* markets. While the voluntary markets trade carbon credits voluntarily, the compliance market is used by companies and government that by law must account for GHG emissions (Seeberg-Elverfeldt, 2010). The regulatory market relies on the three *Kyoto Protocol* mechanisms: Clean Development Mechanism (CDM), Joint Implementation, and the International Emission Trading. The Kyoto Protocol operationalizes the UNFCCC by committing industrialized countries and economies in transition to limit and reduce GHG emissions with agreed individual targets (UNFCCC, 2021c). While carbon credits from CDM projects are called *Certified Emission Reductions* (CER), *Verified Emission Reductions* (VER) are on the voluntary market (Seeberg-Elverfeldt, 2010). Similarly, Reduced Emissions from Deforestation and Forest Degradation (REDD+) expands upon the land use sector in an effort to more effectively implement projects focused on reducing carbon emissions from land use change (Wylie et al., 2016).

687 Using a small-scale blue carbon project, Wylie et al. (2016) show that VERs provide other
688 viable alternatives to UNFCCC's mechanisms that are currently more cost-effective and easier
689 to implement. Other studies have focused on the institutional arrangements related to carbon
690 finance (Peskett et al., 2011), financial development to curb carbon emissions (Chen & Chen,
691 2021; Liu & Liu, 2021), and low-carbon investment challenges (Bolton & Foxon, 2015; Hafner
692 et al., 2020b). For example, Hafner et al. (2020) confirmed that policy uncertainty and short-
693 termism are responsible for low-carbon investments. Besides, Ren et al. (2020) analyzed the
694 relationships between the development level of GF, non-fossil energy, and carbon intensity in
695 China. The results show that non-fossil energy consumption was driven by clear policy effects
696 of GF and carbon intensity but lacked self-driving ability. Similarly, carbon pricing and
697 tradable green certificate are more effective to promote low-carbon renewable energy
698 investments (Tu et al., 2021). The current debate on carbon investment and market is necessary
699 to inform stakeholders on mechanisms, challenges, and strategies to achieving individual
700 emission reduction targets. This presents future opportunities for increased research especially
701 in developing countries and for small-scale carbon reduction projects.
702
703 *4.3.4 Green banking*
704 "Green banking facilitates private investments in domestic low-carbon, climate resilient
705 infrastructure and other green sectors" (OECD, 2016). Green banking has been receiving
706 growing attention both in terms of research and practice. A recent review showed that past
707 green banking studies have focused on "green bank products" and "determinants of green
708 bank" (Akomea-Frimpong et al., 2021). The reviewed studies focused on the role of green
709 banks in green cites (Bazbauers, 2021), barriers and the role of private commercial banks in
710 GF (Zheng et al., 2021), and green loans and green credits of banks (Cui et al., 2018; Zhang et
711 al., 2011; Zhang, 2021). For instance, Zhang et al. (2021) demonstrated that banks' green loan
712 policy significantly pushes highly polluting firms to finance water and gas emission treatment

activities, implying that green loan policy has a positive impact on pollution abatement through financing. Additionally green loans are less-risky than non-green loans, and positively affect the environmental and financial performance of banks by reducing banks' non-performing loan ratio (Cui et al., 2018). Moreover, studies have shown that environmental performance increases the likelihood of eco-friendly firms to receive credits at reduced collateral requirements (Zhang, 2021). Nonetheless, Zheng et al. (2021) discovered that small-scale local businesses find it difficult to access GF until they have demonstrated creditworthiness. In another study, Yip & Bocken (2018) revealed that customers favored three sustainable business archetypes for banking: substitute with digital processes, adopt a stewardship role, and encourage sufficiency. Since the financial institutions are key stakeholders and the largest direct contributors of GF (Zheng et al., 2021), more green banking studies are necessary to promote more low-carbon investments, reduce non-performing loans and transaction costs, and track the environmental performance of green projects. The increasing development of green banks is required for banks to play their chief role in promoting GF through education, sensitization, and increased green investments.

4.3.5 Market stress and GF

Financial markets are usually fraught with instabilities resulting into good/positive and bad/negative news/shocks (Baruník & Křehlík, 2018). Investors therefore prioritize risk consequences of their investment portfolios to effectively manage risk decisions especially during market stress and uncertainty periods (e.g., the COVID-19 pandemic) (Dutta et al., 2021; Gutiérrez Ponce et al., 2021; Mensi et al., 2021; Yi et al., 2021). This is because investors, especially the risk-averse ones, are more concerned about losing their investments during extreme market stress (Naeem et al., 2021). As discussed, GF provides both diversification and hedging benefits (Kuang, 2021; Pham, 2021) necessary for portfolio managers' risk management (Mensi et al., 2021) when developing optimal portfolios to benefit

from investment protection under different market conditions. For instance, a comparative study of US and China showed that, green bonds are long-term sustainable investments that serve as hedging tools against climate risks, financial risks, and rare disasters like COVID-19 (Guo & Zhou, 2021). Additionally, Naeem et al. (2021) revealed that green bond market is more efficient during a black swan event (e.g., COVID-19). This represents the potential of green bonds to become an effective diversifier for investors in traditional assets in times of extreme market turmoil, financial crises, or natural disasters. In particular, sustainable businesses have lower volatility returns, and are less prone to scandals and other reputational fiascos due to their superior risk management (Husse & Pippo, 2021). The discussed GF benefits provide incentives for investors to consider more diverse set of environmentally-friendly investments under both extreme and normal market conditions (Pham, 2021). Besides, Tu et al. (2021) suggest that GF policy mix such as green credit, carbon pricing, and tradable green certificate are still necessary, especially for renewable energy investments, to further improve GF profitability. The growing evidence on GF as a "safe-haven" against financial shocks is important for portfolio management and risk diversification and management in both "good" and "bad" times. Hence, hedging and diversification benefits of GF further represent an incentive – for both pro-environmental investors and those that consider its financial performance – to manage risk. Further, to bridge the GF gap, more financial market stress-related GF studies are needed. Research on the performance of GF during market stress periods, impact of uncertainty measures on the risk management, and policies to mitigate financial contagion during crises to enhance the diversification and hedging benefits of GF could be useful additions to the GF body of knowledge, and to encourage investors.

4.3.6 Domestic and international climate finance policies

Climate finance refers to "local, national or transnational financing – drawn from public, private and alternative sources of financing – that seeks to support mitigation and adaptation

765 actions that will address climate change" (UNFCCC, 2021a). To facilitate the provision of
766 climate finance, *financial mechanisms* to provide financial resources to developing countries
767 have been established by the UNFCCC (UNFCCC, 2021a). Parties have therefore established
768 four special funds: the Special Climate Change Fund, the Least Developed Countries Fund
769 (both managed by the Global Environmental Facility), and the Green Climate Fund under the
770 Convention and the Adaptation Fund under the Kyoto Protocol. Since 2009, developed
771 countries have reaffirmed their promise to provide US$100 billion in international climate
772 finance annually to support developing countries to address climate change (UNFCCC, 2009).
773 Moreover, countries have collectively agreed to take ambitious domestic and international
774 actions to limit the rise in global average temperature to 1.5°C (UNFCCC, 2021b). Hence,
775 research on the mechanisms of domestic and international climate finance policies are on the
776 rise. For instance, some previous studies have investigated the influence of bureaucratic
777 agencies on climate finance allocation (Peterson & Skovgaard, 2019), coastal adaption project
778 design patterns and contributions (Kuhl et al., 2020), economic impacts of climate actions
779 between countries (Román et al., 2019), climate mainstreaming (Bhandary, 2021), the
780 complementarity or disparity between domestic and international climate policies (Peterson,
781 2021), the impact of self-regulation in the adoption of the Equator Principles (Contreras et al.,
782 2019), and the moderating role of politics and the media in climate investment decisions (Bae
783 et al., 2021; Pickering & Mitchell, 2017). It is observed that past studies have focused on the
784 barriers, strategies, and the impact of climate finance at both domestic and international levels.
785 More research on innovative means of applying both domestic and international climate
786 finance to achieve the Paris Agreement goals and sustainable development is needed.
787
788 *4.4. Dimensions or application areas in GF*
789 As pointed out (*see sub-section 3.2.2*), GF is multidisciplinary with studies focusing on
790 multiple research areas such as business and economics, accounting, finance and investment,

and energy, environment, and climate issues. This section provides a detailed analysis of the application areas of the reviewed studies (Appendix A).

First, majority (52%) of the reviewed studies were interdisciplinary focusing on areas such as clean and renewable energy, metals, agriculture, green building, and green firms. This could be due to the lack of or incomplete data on all individual categories from GF databases. For instance, the Environmental Finance database does not contain information of the share of all proceeds allocated to different categories of each issuance. Hence, in using the Environmental Finance database, Torvanger et al. (2021) considered just four categories including energy, green buildings, clean transportation, and circular economy. Aside the interdisciplinary studies, energy (18%), green firms and manufacturing (10%), and green banking (10%) categories received the highest sector-specific attention in the literature. This could be due to the high performance and lower volatility of clean energy companies and investments on financial markets (IEA, 2021). For instance, Kuang (2021) revealed that the risk diversification benefits of clean energy assets provide market-based incentives for investors to decarbonize their equity portfolios and to exchange dirty energy for clean energy assets. On the other hand, banks provide the largest direct contributions to GF (Zheng et al., 2021). Other sector-specific studies focused on green building, coastal protection, forestry, and cybersecurity. The small number of sector-specific studies in the sample provides opportunities for more studies focusing on specific sectors to understand the GF challenges and opportunities peculiar to each sector. For example, Debrah et al. (2022) revealed that GF in green building is a highly under-researched and under-invested area requiring more studies and investment. Figure 11 provides a summary of the GF application areas from the reviewed studies.

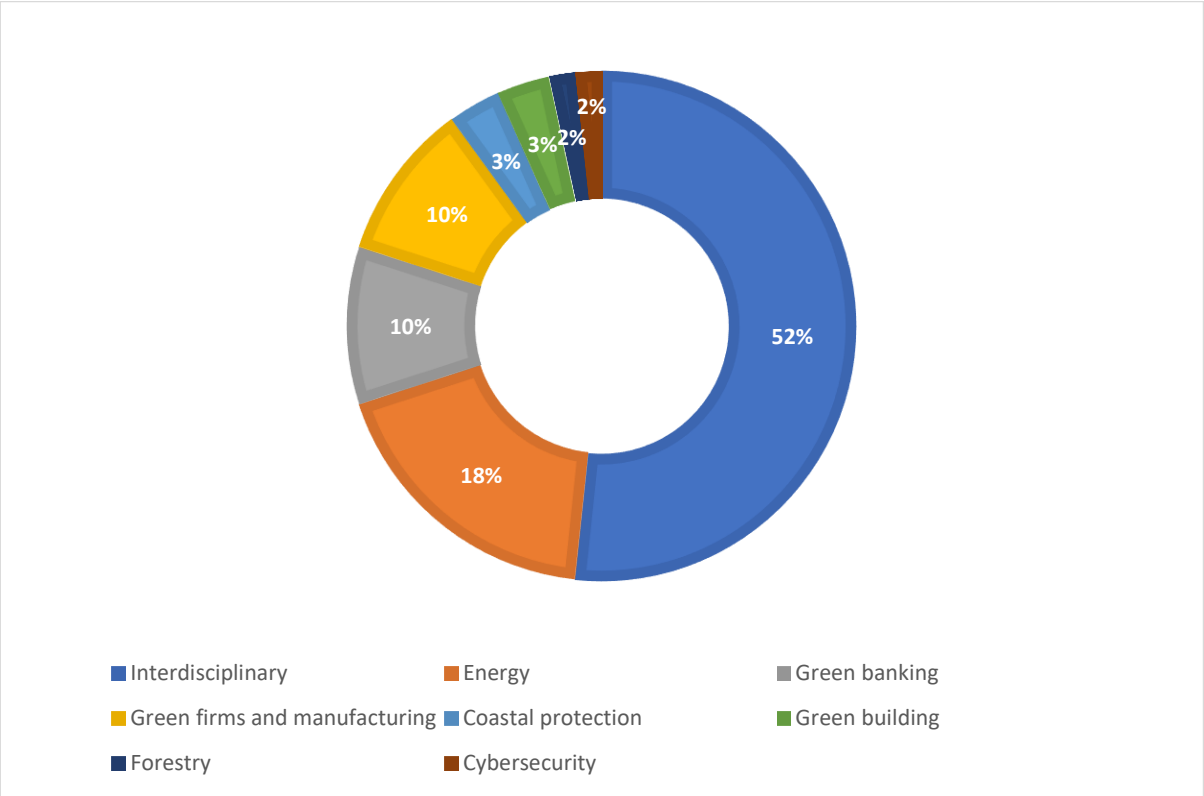


Figure 11. Dimensions or application areas of green finance.

5. GF gaps and future research directions

This study is a bibliometric-qualitative analysis to provide the full picture of research focuses and reveal the gaps and needs regarding GF research. The findings show that the literature on GF is still relatively immature needing more research, especially more sector-specific studies to understand the GF challenges and opportunities in the various fields. It is therefore necessary to identify and investigate significant directions for future research.

Hence, some research gaps, needs, and potential directions for future research are discussed as follows:

1. GF policy initiatives and incentives

GF provides financial assistance to aid the transition to green economy in line with the Paris Agreement. Moreover, increasing environmental challenges have prompted governments to adopt a number of green policy initiatives and incentives in recent years to enhance

environmental performance without diminishing economic growth (Wang & Bernell, 2013; Pueyo, 2018). According to Bhatnagar & Sharma (2022), regulatory reforms and the involvement of local government can significantly support the transition of the financial system and the GF growth. Hence, suitable policies are needed to provide environmental and financial benefits to green investors. This is because GF can only thrive with clear and robust legal frameworks (Sachs et al., 2019). For instance, to increase GF among the private sector and financial institutions, legal regulations should encourage and /or mandate the integration of climate and environmental issues in financial decisions and risk management analysis. This is because GF remains largely government-driven (He et al., 2022). Similarly, financial institutions are encouraged to construct a reasonable and effective GF system and control the green credit volume in the optimal investment range. This is necessary to guide and encourage more social capital into green industries through policy support measures and effective financial system (He et al., 2019; Lv et al., 2021). Hence more GF studies related green credit guarantee schemes (Naeem et al., 2021), tax reliefs, exemptions, and subsidies (Mankata et al., 2020; Tu et al., 2021) are needed to boost private sector participation. While governmental subsidy promotes firms' innovation (Wang et al., 2017), Liu & He (2021) argue that environmental tax regulation suppresses economic expansion. It is therefore critical to understand the trade-offs between environmental regulation and economic growth to guide government policy and regulation. The above gaps reveal that while market mechanisms and state policies may promote GF (Wang et al., 2021), more research is needed to guide regulators and policymakers on strategies to adopt in promoting GF through polices and regulations.

On the other hand, further studies on the risk management mechanisms of green securities and green insurance are required due to market uncertainties which deters firms' innovation (Wang et al., 2017). For instance, while green securities support green industry projects to augment resource allocation in the capital market and the real economy (Shanghai Stock Exchange, 2021), green insurance diversifies and transfers environmental risks (Chen et al.,

2021) and encourages emission-reducing innovation (Mills, 2012). While green insurance cannot improve expected profits (Wang et al., 2017), the risk reduction ability plays an important role in influencing corporate overseas investments (Chen et al., 2021). It thus imperative to explore how green insurance and green securities can be adopted to boost GF investments and manage risks in GF markets especially during market stress periods such as the COVID-19. Research on theories related to green insurance and green securities (Chen et al., 2021) and the effects on GF market structure present interesting opportunities for future studies.

As noted above, GF policies and incentives are key in developing strong financial systems that encourage both the private and public sector participation in decarbonizing their investments. Hence it is suggested that policymakers scale-up appropriate environmental policies to enhance the GF market and make it more resilient to shocks (Naeem et al., 2021). Such policies and incentives will significantly support the development and growth of GF.

2. GF in green building

A 'green' building is a "building that, in its design, construction or operation, reduces or eliminates negative impacts, and can create positive impacts, on our climate and natural environment" (World Green Building Council, 2022). *Green building* has become necessary due to unsustainability and inefficiency of the construction sector which accounts for the largest share of both energy use (36%) and carbon emissions (37%) in the world (UNEP, 2021). Moreover, the ICMA (2018) identifies green building as an eligible GF project leading to increasing investment. However, GF in green building remains under-invested and under-researched (Debrah et al., 2022a). For instance, global investment in green building accounted for US$148 billion of the US$5.6 trillion investment on building construction and renovation in 2019 (UNEP, 2020). Similarly, Likhacheva Sokolowski et al. (2019) recount that green buildings represent only a fraction of the US$ 24.7 trillion investment opportunity by 2030.

This huge investment gap calls for the need to investigate why green building lacks the needed GF. Such studies will increase the understanding of developers, investors, owners, and the government on GF in green building. This will promote the development of green building via the application of GF instruments such as green fiscal investment, green credit, green insurance, and green bonds (He et al., 2022). Increased green building related research that focuses on the debt market (An & Pivo, 2020) will help developers and investors to understand the present GF challenges and opportunities in green building. Again, in using real case examples, favorable economic (investment returns) and lower interest rates associated with GF (Akomea-Frimpong et al., 2022) can be modelled to assess the economic feasibility of GF in green building projects (Taghizadeh-Hesary et al., 2022). Additionally, to increase GF in green building econometric studies and archival data analysis, improved databases on GF in green building is necessary. Such databases could promote research on the impact of green building finance on carbon emissions (Gholipour et al., 2022), economic feasibility studies (An & Pivo, 2020), and time series econometrics (He et al., 2022) of GF in green building at both national and international levels. Besides, the challenges associated with analyzing investment risks of GF in green building could be reduced with adequate data (Akomea-Frimpong et al., 2022). Additionally, future studies may evaluate the costs and benefits of GF in green building (Debrah et al., 2022a). Also, future research that focuses on GF in green building certification or rating system is critical (Debrah et al., 2022a) in clarifying what constitutes GF in green building and the difficulty in ascertaining GF certification (Akomea-Frimpong et al., 2022). The rising interest of stakeholders such as government, investors, and green building developers in GF open up opportunities for increased GF in green building research and development. This critical to explore the reported investment gap of GF in building and the associated research needs.

3. Fintech-for-GF

There is growing research in technological development and artificial intelligence (Debrah et al., 2022b), more particularly, financial technology (fintech). *Fintech* refers to technology-enabled financial solutions (Arner et al., 2015). This comprises digital innovation and modern technology to improve, develop, and automate financial services. It is used to assist and support firms, investors, and customers in managing their financial activities using specialized applications and software (Al Hammadi & Nobanee, 2019) that are more user-friendly, efficient, and transparent (Moro-Visconti et al., 2020). As such, the integration of fintech and GF using technologies such as artificial intelligence (AI), blockchain, cloud computing, big data, and Internet of Things are critical (He et al., 2020). However, its application in GF is limited. According to Macpherson et al. (2021), the challenges of the COVID-19 pandemic present opportunities to rethink and explore the potentials of integrating fintech and GF. Besides, fintech can revolutionise GF to promote efficient industrial performance and effective resource utilization (Bhatnagar et al., 2021). It has the capacity to fill the technological gap in GF and create investment opportunities (Bhatnagar & Sharma, 2022). For example, through fintech, GF challenges such as information asymmetry could be reduced by establishing GF databases to promote effective communication and coordination between parties (Xueqing, 2021). This will promote mature information disclosure system for GF. Additionally, fintech could facilitate real-time tracking and monitoring of enterprises participating in green credit. With fintech, GF-related information can be updated in real-time (He et al., 2020), reduce identification and transaction costs of green economic activities (Xueqing, 2021). The outcomes of fintech for GF will thus to be well-suited to investor needs, customise GF processes and investment decisions. Moreover, the transparency that comes with improved technological capabilities in gathering and analyzing data through AI techniques such as machine learning will foster transparency and make GF more efficient (Husse & Pippo, 2021), thereby diminishing many of the existing problems such as "*greenwashing*" – the issuance of so-called green securities that lack genuine environmental benefits (Larcker & Watts, 2020).

Further, AI and blockchain technologies can be leveraged in developing an intelligent GF rating tool as a significant valuation tool to reflect the real-time GF market value to both investors and issuers (Debrah et al., 2022a). Additionally, GF-fintech related studies such as big data-based asset-level information, robo-advisory, crowdfunding, distributed ledger technology, environmental risk assessment and pricing, ethical guidelines for trustworthy fintech-for-GF, and policy and regulatory considerations would increase our understanding of the area. Emerging AI- and fintech-related technologies could provide opportunities and common platforms for regulators, standard setters, investors, financial institutions, and project developers to promote GF. Since fintech-for-GF is emerging, further research is needed to provide more insights to stakeholders.

6. Conclusions and Limitations

This study explored the state-of-the-art GF research hotspots and identified gaps that could be addressed in future research. This study adopted a bibliometric-qualitative systematic analysis to review the now-available GF literature. The mixed-methods bibliometric-systematic review was effective in limiting subjectivity in the analysis and the ability to replicate similar studies in future. The database search was conducted using searches from Scopus database and validated with data from three other academic databases including Web of Science, Google Scholar, and ScienceDirect from 1989 to March 2021.

Theoretically, this study identified six major themes of GF research: “green bond market and greenium”, “green credit (loan)”, “carbon investment and market”, “green banking”, “market stress and GF (e.g., the COVID-19)” and “domestic and international climate finance policies”. We show that GF research so-far has been underpinned by evolutionary economics and ecological finance theories. Although GF has shown great relevance in recent times with a steady growth, the findings depict an immature research area that demands a renewed focus from the academic community. Basically, this study serves as an up-to-the-minute reference

point for GF. The study identified key areas and knowledge gaps in GF-research. The results obtained thus serve as a guideline for practitioners and policymakers to evaluate their level of development in terms of GF and analyse their shortcoming in terms of developing a GF economy. The findings thus set the tone for further studies by providing paths and recommendations for future studies in GF. The recommendations (GF policy initiatives and incentives; GF in green building; and fintech-for-GF) provide fertile grounds for both researchers and practitioners to explore the emerging aspects of GF to promote research and development.

Despite the contributions, this study still has limitations which should be considered when interpreting the results of this study. The analysis was limited to journal articles. To improve this study, future studies may combine different document types. Additionally, the literature searches were based on specific keywords that may not reflect the full picture of the research area. Future research may include more keywords.

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References

Akomea-Frimpong, I., Adeabah, D., Ofosu, D., & Tenakwah, E. J. (2021). A review of studies on green finance of banks, research gaps and future directions. *Journal of Sustainable Finance and Investment*. https://doi.org/10.1080/20430795.2020.1870202

Akomea-Frimpong, I., Kukah, A. S., Jin, X., Osei-Kyei, R., & Pariafsai, F. (2022). Green finance for green buildings: A systematic review and conceptual foundation. *Journal of Cleaner Production, 356*, 131869. https://doi.org/10.1016/j.jclepro.2022.131869

Al Hammadi, T., & Nobanee, H. (2019). *FinTech and Sustainability: A Mini-Review* (SSRN Scholarly Paper ID 3500873). Social Science Research Network. https://doi.org/10.2139/ssrn.3500873

Ameli, N., Drummond, P., Bisaro, A., Grubb, M., & Chenet, H. (2020). Climate finance and disclosure for institutional investors: Why transparency is not enough. *Climatic Change*, *160*(4), 565–589. https://doi.org/10.1007/s10584-019-02542-2

An, X., & Pivo, G. (2020). Green Buildings in Commercial Mortgage-Backed Securities: The Effects of LEED and Energy Star Certification on Default Risk and Loan Terms. *Real Estate Economics*, *48*(1), 7–42. https://doi.org/10.1111/1540-6229.12228

Antwi-Afari, P., Ng, S. T., & Hossain, Md. U. (2021). A review of the circularity gap in the construction industry through scientometric analysis. *Journal of Cleaner Production, 298*, 126870. https://doi.org/10.1016/j.jclepro.2021.126870

Arner, D. W., Barberis, J., & Buckley, R. P. (2015). The Evolution of FinTech: A New Post-Crisis Paradigm. *Georgetown Journal of International Law*, *47*, 1271.

Bae, S. M., Masud, M. A. K., Rashid, M. H. U., & Kim, J. D. (2021). Determinants of climate financing and the moderating effect of politics: Evidence from Bangladesh. *Sustainability Accounting, Management and Policy Journal*.

Baruník, J., & Křehlík, T. (2018). Measuring the Frequency Dynamics of Financial Connectedness and Systemic Risk*. *Journal of Financial Econometrics*, *16*(2), 271–296. https://doi.org/10.1093/jjfinec/nby001

Bastian, M., Heymann, S., & Jacomy, M. (2009). Gephi: An Open Source Software for Exploring and Manipulating Networks. *Proceedings of the International AAAI Conference on Web and Social Media*, *3*(1), Article 1. https://ojs.aaai.org/index.php/ICWSM/article/view/13937

Bazbauers, A. R. (2021). Sustainable, green, and climate-resilient cities: An analysis of multilateral development banks. *Climate and Development*, *0*(0), 1–16. https://doi.org/10.1080/17565529.2021.1974331

Bhandary, R. R. (2021). Climate mainstreaming via national climate funds: The experiences of Bangladesh and Ethiopia. *Climate and Development*, *0*(0), 1–10. https://doi.org/10.1080/17565529.2021.1921686

Bhatnagar, S., & Sharma, D. (2022). Evolution of green finance and its enablers: A bibliometric analysis. *Renewable and Sustainable Energy Reviews*, *162*, 112405. https://doi.org/10.1016/j.rser.2022.112405

Bhatnagar, S., Sharma, D., & Agrawal, S. (2021). Can Industry 4.0 Revolutionize the Wave of Green Finance Adoption: A Bibliometric Analysis. In R. Agrawal, J. K. Jain, V. S. Yadav, V. K. Manupati, & L. Varela (Eds.), *Recent Advances in Smart Manufacturing and Materials* (pp. 515–525). Springer. https://doi.org/10.1007/978-981-16-3033-0_49

Bhutta, U. S., Tariq, A., Farrukh, M., Raza, A., & Iqbal, M. K. (2022). Green bonds for sustainable development: Review of literature on development and impact of green bonds. *Technological Forecasting and Social Change*, *175*, 121378. https://doi.org/10.1016/j.techfore.2021.121378

Bolton, R., & Foxon, T. J. (2015). A socio-technical perspective on low carbon investment challenges—Insights for UK energy policy. *Environmental Innovation and Societal Transitions*, *14*, 165–181. https://doi.org/10.1016/j.eist.2014.07.005

Cai, R., & Guo, J. (2021). Finance for the Environment: A Scientometrics Analysis of Green Finance. *Mathematics*, *9*(13), 1537. https://doi.org/10.3390/math9131537

CBI. (2021). *Climate Bonds Initiative*. Climate Bonds Initiative. https://www.climatebonds.net/

Chen, C. (2006). CiteSpace II: Detecting and visualizing emerging trends and transient patterns in scientific literature. *Journal of the American Society for Information Science and Technology*, *57*(3), 359–377. https://doi.org/10.1002/asi.20317

Chen, C. (2014). *CiteSpace Manual*. http://cluster.ischool.drexel.edu/%7Ecchen/citespace/CiteSpaceManual.pdf

Chen, Q., Ning, B., Pan, Y., & Xiao, J. (2021). Green finance and outward foreign direct investment: Evidence from a quasi-natural experiment of green insurance in China. *Asia Pacific Journal of Management*. https://doi.org/10.1007/s10490-020-09750-w

Chen, X., & Chen, Z. (2021). Can Green Finance Development Reduce Carbon Emissions? Empirical Evidence from 30 Chinese Provinces. *Sustainability*, *13*(21), 12137. https://doi.org/10.3390/su132112137

Chiesa, M., & Barua, S. (2019). The surge of impact borrowing: The magnitude and determinants of green bond supply and its heterogeneity across markets. *Journal of Sustainable Finance and Investment*, *9*(2), 138–161. https://doi.org/10.1080/20430795.2018.1550993

China Banking Regulatory Commission. (2012). *Notice of the China Banking Regulatory Commission Cbrc on Issuing the Green Credit Guidelines; China Banking Regulatory Commission: Beijing, China*.

Cobo, M. J., López-Herrera, A. G., Herrera-Viedma, E., & Herrera, F. (2011). Science mapping software tools: Review, analysis, and cooperative study among tools. *Journal of the American Society for Information Science and Technology*, *62*(7), 1382–1402. https://doi.org/10.1002/asi.21525

Contreras, G., Bos, J. W. B., & Kleimeier, S. (2019). Self-regulation in sustainable finance: The adoption of the Equator Principles. *World Development*, *122*, 306–324. https://doi.org/10.1016/j.worlddev.2019.05.030

Cui, Y., Geobey, S., Weber, O., & Lin, H. (2018). The impact of green lending on credit risk in China. *Sustainability (Switzerland)*, *10*(6). https://doi.org/10.3390/su10062008

Darko, A., & Chan, A. P. C. (2016). Critical analysis of green building research trend in construction journals. *Habitat International*, *57*, 53–63. https://doi.org/10.1016/j.habitatint.2016.07.001

Darko, A., & Chan, A. P. C. (2021). Applying science mapping in built environment research. In *Secondary Research Methods in the Built Environment* (pp. 117–132). Routledge. https://doi.org/10.1201/9781003000532-9

Darko, A., Chan, A. P. C., Adabre, M. A., Edwards, D. J., Hosseini, M. R., & Ameyaw, E. E. (2020). Artificial intelligence in the AEC industry: Scientometric analysis and visualization of research activities. *Automation in Construction*, *112*, 103081. https://doi.org/10.1016/j.autcon.2020.103081

Debrah, C., Chan, A. P. C., & Darko, A. (2022a). Green finance gap in green buildings: A scoping review and future research needs. *Building and Environment*, *207*, 108443. https://doi.org/10.1016/j.buildenv.2021.108443

Debrah, C., Chan, A. P. C., & Darko, A. (2022b). Artificial intelligence in green building. *Automation in Construction*, *137*, 104192. https://doi.org/10.1016/j.autcon.2022.104192

1084 Ding, Y. (2011). Scientific collaboration and endorsement: Network analysis of coauthorship
1085 and citation networks. *Journal of Informetrics*, *5*(1), 187–203.
1086 https://doi.org/10.1016/j.joi.2010.10.008
1087 Dutta, A., Bouri, E., Dutta, P., & Saeed, T. (2021). Commodity market risks and green
1088 investments: Evidence from India. *Journal of Cleaner Production*, *318*, 128523.
1089 https://doi.org/10.1016/j.jclepro.2021.128523
1090 European Commission. (2016, November 23). *EU Emissions Trading System (EU ETS)* [Text].
1091 Climate Action - European Commission. https://ec.europa.eu/clima/policies/ets_en
1092 Fama, E. F. (1970). Efficient market hypothesis: A review of theory and empirical work.
1093 *Journal of Finance*, *25*(2), 28–30.
1094 Feldman, R. D. (1989). Paying for cleanup: Tools for confronting environmental finance issues.
1095 *Journal of the Air Pollution Control Association*, *39*(6), 810–812.
1096 https://doi.org/10.1080/08940630.1989.10466565
1097 Ferrer, R., Shahzad, S. J. H., & Soriano, P. (2021). Are green bonds a different asset class?
1098 Evidence from time-frequency connectedness analysis. *Journal of Cleaner Production*,
1099 *292*. https://doi.org/10.1016/j.jclepro.2021.125988
1100 Flammer, C. (2021). Corporate green bonds. *Journal of Financial Economics*.
1101 https://doi.org/10.1016/j.jfineco.2021.01.010
1102 Foxon, T. J. (2011). A coevolutionary framework for analysing a transition to a sustainable low
1103 carbon economy. *Ecological Economics*, *70*(12), 2258–2267.
1104 https://doi.org/10.1016/j.ecolecon.2011.07.014
1105 Gholipour, H. F., Arjomandi, A., & Yam, S. (2022). Green property finance and CO2 emissions
1106 in the building industry. *Global Finance Journal*, *51*, 100696.
1107 https://doi.org/10.1016/j.gfj.2021.100696

Gilchrist, D., Yu, J., & Zhong, R. (2021). The limits of green finance: A survey of literature in the context of green bonds and green loans. *Sustainability*, *13*(2), 1–12. https://doi.org/10.3390/su13020478

Greene, J. C., Caracelli, V. J., & Graham, W. F. (1989). Toward a Conceptual Framework for Mixed-Method Evaluation Designs. *Educational Evaluation and Policy Analysis*, *11*(3), 255–274. https://doi.org/10.3102/01623737011003255

Grubb, M., Hourcade, J. C., & Neuhoff, K. (2014). *Planetary economics: Energy, climate change and the three domains of sustainable development.* Routledge, London, UK.

Grubb, M., Hourcade, J.-C., & Neuhoff, K. (2015). The Three Domains structure of energy-climate transitions. *Technological Forecasting and Social Change*, *98*, 290–302. https://doi.org/10.1016/j.techfore.2015.05.009

Guo, D., & Zhou, P. (2021). Green bonds as hedging assets before and after COVID: A comparative study between the US and China. *Energy Economics*, *104*, 105696. https://doi.org/10.1016/j.eneco.2021.105696

Gutiérrez Ponce, H., Chamizo González, J., & Al-Mohareb, M. (2021). Sustainable finance in cybersecurity investment for future profitability under uncertainty. *Journal of Sustainable Finance & Investment*, *0*(0), 1–20. https://doi.org/10.1080/20430795.2021.1985951

Hafner, S., Jones, A., Anger-Kraavi, A., & Pohl, J. (2020a). Closing the green finance gap – A systems perspective. *Environmental Innovation and Societal Transitions*, *34*, 26–60. https://doi.org/10.1016/j.eist.2019.11.007

Hafner, S., Jones, A., Anger-Kraavi, A., & Pohl, J. (2020b). Closing the green finance gap – A systems perspective. *Environmental Innovation and Societal Transitions*, *34*, 26–60. https://doi.org/10.1016/j.eist.2019.11.007

Hall, S., Foxon, T. J., & Bolton, R. (2017). Investing in low-carbon transitions: Energy finance as an adaptive market. *Climate Policy*, *17*(3), 280–298. https://doi.org/10.1080/14693062.2015.1094731

Harden, A., & Thomas, J. (2010). Mixed Methods and Systematic Reviews: Examples and Emerging Issues. In A. Tashakkori & C. Teddlie, *SAGE Handbook of Mixed Methods in Social & Behavioral Research* (pp. 749–774). SAGE Publications, Inc. https://doi.org/10.4135/9781506335193.n29

He, L., Zhang, L., Zhong, Z., Wang, D., & Wang, F. (2019). Green credit, renewable energy investment and green economy development: Empirical analysis based on 150 listed companies of China. *Journal of Cleaner Production*, *208*, 363–372. https://doi.org/10.1016/j.jclepro.2018.10.119

He, W., Liu, P., Lin, B., Zhou, H., & Chen, X. (2022). Green finance support for development of green buildings in China: Effect, mechanism, and policy implications. *Energy Policy*, *165*, 112973. https://doi.org/10.1016/j.enpol.2022.112973

He, Z., Liu, Z., Wu, H., Gu, X., Zhao, Y., & Yue, X. (2020). Research on the Impact of Green Finance and Fintech in Smart City. *Complexity*, *2020*, e6673386. https://doi.org/10.1155/2020/6673386

Heyvaert, M., Hannes, K., & Onghena, P. (2016). *Using Mixed Methods Research Synthesis for Literature Reviews: The Mixed Methods Research Synthesis Approach*. SAGE Publications.

Hosseini, M. R., Martek, I., Zavadskas, E. K., Aibinu, A. A., Arashpour, M., & Chileshe, N. (2018). Critical evaluation of off-site construction research: A Scientometric analysis. *Automation in Construction*, *87*, 235–247. https://doi.org/10.1016/j.autcon.2017.12.002

Hu, G., Wang, X., & Wang, Y. (2021). Can the green credit policy stimulate green innovation in heavily polluting enterprises? Evidence from a quasi-natural experiment in China. *Energy Economics*, *98*, 105134.

Husse, T., & Pippo, F. (2021). Responsible Minus Irresponsible—A determinant of equity risk premia? *Journal of Sustainable Finance & Investment*, *0*(0), 1–23. https://doi.org/10.1080/20430795.2021.1961557

Hyun, S., Park, D., & Tian, S. (2020). The price of going green: The role of greenness in green bond markets. *Accounting and Finance*, *60*(1), 73–95. https://doi.org/10.1111/acfi.12515

ICMA. (2018). *Green Bond Principles*. https://www.icmagroup.org/sustainable-finance/the-principles-guidelines-and-handbooks/green-bond-principles-gbp/

ICMA. (2020). *Sustainable Finance High-level definitions*. https://www.icmagroup.org/sustainable-finance/icma-publications/

IEA. (2021). *World Energy Investment 2021 – Analysis*. IEA. https://www.iea.org/reports/world-energy-investment-2021

IFC. (2019). *Green Buildings: A Finance and Policy Blueprint for Emerging Markets*. The World Bank.

Ji, Q., & Zhang, D. (2019). How much does financial development contribute to renewable energy growth and upgrading of energy structure in China? *Energy Policy*, *128*, 114–124. https://doi.org/10.1016/j.enpol.2018.12.047

Kawabata, T. (2019). What are the determinants for financial institutions to mobilise climate finance? *Journal of Sustainable Finance and Investment*, *9*(4), 263–281. https://doi.org/10.1080/20430795.2019.1611148

Kirchherr, J. W., & van Santen, R. (2019). Research on the Circular Economy: A Critique of the Field. *Resources, Conservation and Recycling*, *151*. https://doi.org/10.1016/j.resconrec.2019.104480

Kuang, W. (2021). Are clean energy assets a safe haven for international equity markets? *Journal of Cleaner Production*, 127006.

Kuhl, L., Van Maanen, K., & Scyphers, S. (2020). An analysis of UNFCCC-financed coastal adaptation projects: Assessing patterns of project design and contributions to adaptive capacity. *World Development*, *127*. https://doi.org/10.1016/j.worlddev.2019.104748

Lagoarde-Segot, T., & Martínez, E. A. (2021). Ecological finance theory: New foundations. *International Review of Financial Analysis*, *75*, 101741. https://doi.org/10.1016/j.irfa.2021.101741

Larcker, D. F., & Watts, E. M. (2020). Where's the greenium? *Journal of Accounting and Economics*, *69*(2–3). https://doi.org/10.1016/j.jacceco.2020.101312

Lau, P., Sze, A., Wan, W., & Wong, A. (2022). The Economics of the Greenium: How Much is the World Willing to Pay to Save the Earth? *Environmental and Resource Economics*, *81*(2), 379–408. https://doi.org/10.1007/s10640-021-00630-5

Lawson, T. (2019). *The Nature of Social Reality: Issues in Social Ontology*. Routledge. https://doi.org/10.4324/9780429199035

Li, Z., Liao, G., Wang, Z., & Huang, Z. (2018). Green loan and subsidy for promoting clean production innovation. *Journal of Cleaner Production*, *187*, 421–431. https://doi.org/10.1016/j.jclepro.2018.03.066

Liang, C., Luo, A., & Zhong, Z. (2018). Knowledge mapping of medication literacy study: A visualized analysis using CiteSpace. *SAGE Open Medicine*, *6*. https://doi.org/10.1177/2050312118800199

Liu, L., & He, L.-Y. (2021). Output and welfare effect of green credit in China: Evidence from an estimated DSGE model. *Journal of Cleaner Production*, *294*. https://doi.org/10.1016/j.jclepro.2021.126326

Liu, X., & Liu, X. (2021). Can Financial Development Curb Carbon Emissions? Empirical Test Based on Spatial Perspective. *Sustainability*, *13*(21), 11912. https://doi.org/10.3390/su132111912

Lo, A. W. (2012). Adaptive Markets and the New World Order (corrected May 2012). *Financial Analysts Journal*, *68*(2), 18–29. https://doi.org/10.2469/faj.v68.n2.6

Loan Market Association. (2021). Guidance on Green Loan Principles (GLP). *LSTA*. https://www.lsta.org/content/guidance-on-green-loan-principles-glp/#

Lv, C., Bian, B., Lee, C.-C., & He, Z. (2021). Regional gap and the trend of green finance development in China. *Energy Economics*, *102*, 105476. https://doi.org/10.1016/j.eneco.2021.105476

MacAskill, S., Roca, E., Liu, B., Stewart, R. A., & Sahin, O. (2021). Is there a green premium in the green bond market? Systematic literature review revealing premium determinants. *Journal of Cleaner Production*, *280*. https://doi.org/10.1016/j.jclepro.2020.124491

MacAskill, S., Sahin, O., Stewart, R. A., Roca, E., & Liu, B. (2021). Examining green affordable housing policy outcomes in Australia: A systems approach. *Journal of Cleaner Production*, *293*. https://doi.org/10.1016/j.jclepro.2021.126212

Macpherson, M., Gasperini, A., & Bosco, M. (2021). *Artificial Intelligence and FinTech Technologies for ESG Data and Analysis* (SSRN Scholarly Paper ID 3790774). Social Science Research Network. https://doi.org/10.2139/ssrn.3790774

Mankata, L. M., Owusu-Manu, D.-G., Hosseini, M. R., & Edwards, D. J. (2020). Analysis of success-dependent factors for green bond financing of infrastructure projects in Ghana. *Journal of Sustainable Finance and Investment*. https://doi.org/10.1080/20430795.2020.1803640

Meho, L. I., & Rogers, Y. (2008). Citation counting, citation ranking, and h-index of human-computer interaction researchers: A comparison of Scopus and Web of Science.

Journal of the American Society for Information Science and Technology, *59*(11), 1711–1726. https://doi.org/10.1002/asi.20874

Mensi, W., Vo, X. V., & Kang, S. H. (2021). Upside-Downside Multifractality and Efficiency of Green Bonds: The Roles of Global Factors and COVID-19. *Finance Research Letters*, *43*, 101995. https://doi.org/10.1016/j.frl.2021.101995

Mills, E. (2012). The Greening of Insurance. *Science*, *338*(6113), 1424–1425. https://doi.org/10.1126/science.1229351

Moro-Visconti, R., Cruz Rambaud, S., & López Pascual, J. (2020). Sustainability in FinTechs: An Explanation through Business Model Scalability and Market Valuation. *Sustainability*, *12*(24), 10316. https://doi.org/10.3390/su122410316

Naeem, M. A., Adekoya, O. B., & Oliyide, J. A. (2021). Asymmetric spillovers between green bonds and commodities. *Journal of Cleaner Production*, *314*, 128100. https://doi.org/10.1016/j.jclepro.2021.128100

Naeem, M. A., Nguyen, T. T. H., Nepal, R., Ngo, Q.-T., & Taghizadeh–Hesary, F. (2021). Asymmetric relationship between green bonds and commodities: Evidence from extreme quantile approach. *Finance Research Letters*. https://doi.org/10.1016/j.frl.2021.101983

Nelson, R. R., & Winter, S., G. (1985). *An Evolutionary Theory of Economic Change*. Harvard University Press.

Noh, H. J. (2019). Financial strategies to accelerate green growth. *Handbook of Green Finance. Sustainable Development. Springer, Singapore*.

OECD. (2016). *Green Investment Banks: Scaling up Private Investment in Low-carbon, Climate-resilient Infrastructure | en | OECD*. https://www.oecd.org/environment/cc/green-investment-banks-9789264245129-en.htm

Oraee, M., Hosseini, M. R., Papadonikolaki, E., Palliyaguru, R., & Arashpour, M. (2017). Collaboration in BIM-based construction networks: A bibliometric-qualitative literature review. *International Journal of Project Management*, *35*(7), 1288–1301. https://doi.org/10.1016/j.ijproman.2017.07.001

Owusu-Manu, D.-G., Mankata, L., Edwards, D., El-Gohary, H., & Hussain, J. (2021). A Cognizance of Green Bond Features Preferential to Renewable Energy Project Financing in Ghana. *IEEE Transactions on Engineering Management*, 1–12. https://doi.org/10.1109/TEM.2021.3080630

Pan, Y., & Zhang, L. (2021). Roles of artificial intelligence in construction engineering and management: A critical review and future trends. *Automation in Construction*, *122*, 103517. https://doi.org/10.1016/j.autcon.2020.103517

Peskett, L., Schreckenberg, K., & Brown, J. (2011). Institutional approaches for carbon financing in the forest sector: Learning lessons for REDD+ from forest carbon projects in Uganda. *Environmental Science and Policy*, *14*(2), 216–229. https://doi.org/10.1016/j.envsci.2010.10.004

Peterson, L. (2021). Domestic and international climate policies: Complementarity or disparity? *International Environmental Agreements: Politics, Law and Economics*. https://doi.org/10.1007/s10784-021-09542-7

Peterson, L., & Skovgaard, J. (2019). Bureaucratic politics and the allocation of climate finance. *World Development*, *117*, 72–97. https://doi.org/10.1016/j.worlddev.2018.12.011

Pham, L. (2021). Frequency connectedness and cross-quantile dependence between green bond and green equity markets. *Energy Economics*, 105257.

Pham, L., & Luu Duc Huynh, T. (2020). How does investor attention influence the green bond market? *Finance Research Letters*, *35*. https://doi.org/10.1016/j.frl.2020.101533

Pickering, J., & Mitchell, P. (2017). What drives national support for multilateral climate finance? International and domestic influences on Australia's shifting stance. *International Environmental Agreements: Politics, Law and Economics*, *17*(1), 107–125. https://doi.org/10.1007/s10784-016-9346-5

Prell, C. (2012). *Social Network Analysis: History, Theory and Methodology*. SAGE.

Pueyo, A. (2018). What constrains renewable energy investment in Sub-Saharan Africa? A comparison of Kenya and Ghana. *World Development*, *109*, 85–100. https://doi.org/10.1016/j.worlddev.2018.04.008

Rannou, Y., Boutabba, M. A., & Barneto, P. (2021). Are Green Bond and Carbon Markets in Europe complements or substitutes? Insights from the activity of power firms. *Energy Economics*, *104*, 105651. https://doi.org/10.1016/j.eneco.2021.105651

Reboredo, J. C. (2018). Green bond and financial markets: Co-movement, diversification and price spillover effects. *Energy Economics*, *74*, 38–50. https://doi.org/10.1016/j.eneco.2018.05.030

Reboredo, J. C., & Ugolini, A. (2020). Price connectedness between green bond and financial markets. *Economic Modelling*, *88*, 25–38. https://doi.org/10.1016/j.econmod.2019.09.004

Reboredo, J. C., Ugolini, A., & Aiube, F. A. L. (2020). Network connectedness of green bonds and asset classes. *Energy Economics*, *86*, 104629. https://doi.org/10.1016/j.eneco.2019.104629

Ren, X., Shao, Q., & Zhong, R. (2020). Nexus between green finance, non-fossil energy use, and carbon intensity: Empirical evidence from China based on a vector error correction model. *Journal of Cleaner Production*, *277*, 122844. https://doi.org/10.1016/j.jclepro.2020.122844

Román, M. V., Arto, I., & Ansuategi, A. (2019). International trade and the distribution of economy-wide benefits from the disbursement of climate finance. *Climate and Development*, *11*(8), 639–654. https://doi.org/10.1080/17565529.2018.1521330

Rządkowski, G., Głażewska, I., & Sawińska, K. (2015). The Gompertz Function And Its Applications In Management. *Foundations of Management*, *7*(1), 185–190. https://doi.org/10.1515/fman-2015-0035

Sachs, J. D., Woo, W. T., Yoshino, N., & Taghizadeh-Hesary, F. (2019). *Why Is Green Finance Important?* (SSRN Scholarly Paper No. 3327149). Social Science Research Network. https://doi.org/10.2139/ssrn.3327149

Sarma, P., & Roy, A. (2021). A Scientometric analysis of literature on Green Banking (1995-March 2019). *Journal of Sustainable Finance & Investment*, *11*(2), 143–162. https://doi.org/10.1080/20430795.2020.1711500

Seeberg-Elverfeldt, C. (2010). Carbon markets-which types exist and how they work. *Carbon Finance Possibilities for Agriculture, Forestry and Other Land Use Projects in a Smallholder Context*.

Shanghai Stock Exchange. (2021). *Green Securities*. http://english.sse.com.cn/markets/greensecurities/

Sheng, Q., Zheng, X., & Zhong, N. (2021). Financing for sustainability: Empirical analysis of green bond premium and issuer heterogeneity. *Natural Hazards*. https://doi.org/10.1007/s11069-021-04540-z

Simon, H. A. (1990). Bounded Rationality. In J. Eatwell, M. Milgate, & P. Newman (Eds.), *Utility and Probability* (pp. 15–18). Palgrave Macmillan UK. https://doi.org/10.1007/978-1-349-20568-4_5

Song, M., Xie, Q., & Shen, Z. (2021). Impact of green credit on high-efficiency utilization of energy in China considering environmental constraints. *Energy Policy*, *153*, 112267.

Su, H.-N., & Lee, P.-C. (2010). Mapping knowledge structure by keyword co-occurrence: A first look at journal papers in Technology Foresight. *Scientometrics*, *85*(1), 65–79. https://doi.org/10.1007/s11192-010-0259-8

Taghizadeh-Hesary, F., Li, Y., Rasoulinezhad, E., Mortha, A., Long, Y., Lan, Y., Zhang, Z., Li, N., Zhao, X., & Wang, Y. (2022). Green finance and the economic feasibility of hydrogen projects. *International Journal of Hydrogen Energy*. https://doi.org/10.1016/j.ijhydene.2022.01.111

Taghizadeh-Hesary, F., Yoshino, N., & Phoumin, H. (2021). Analyzing the Characteristics of Green Bond Markets to Facilitate Green Finance in the Post-COVID-19 World. *Sustainability*, *13*(10), 5719. https://doi.org/10.3390/su13105719

Tolliver, C., Keeley, A. R., & Managi, S. (2020). Drivers of green bond market growth: The importance of Nationally Determined Contributions to the Paris Agreement and implications for sustainability. *Journal of Cleaner Production*, *244*. https://doi.org/10.1016/j.jclepro.2019.118643

Torvanger, A., Maltais, A., & Marginean, I. (2021). Green bonds in Sweden and Norway: What are the success factors? *Journal of Cleaner Production*, *324*, 129177. https://doi.org/10.1016/j.jclepro.2021.129177

Tu, Q., Mo, J., Liu, Z., Gong, C., & Fan, Y. (2021). Using green finance to counteract the adverse effects of COVID-19 pandemic on renewable energy investment-The case of offshore wind power in China. *Energy Policy*, *158*, 112542. https://doi.org/10.1016/j.enpol.2021.112542

UNEP. (2015). *Towards a Theory of Sustainable Finance*. UNEP - UN Environment Programme. http://www.unep.org/resources/report/towards-theory-sustainable-finance

UNEP. (2017). *Green Finance Opportunities in ASEAN*. 90.

UNEP. (2020). *2020 Global Status Report for Buildings and Construction: Towards a Zero-emission, Efficient and Resilient Buildings and Construction Sector.*

https://globalabc.org/sites/default/files/inline-files/2020%20Buildings%20GSR_FULL%20REPORT.pdf

UNEP. (2021, October 19). *2021 Global Status Report for Buildings and Construction*. UNEP - UN Environment Programme. http://www.unep.org/resources/report/2021-global-status-report-buildings-and-construction

UNFCCC. (2009). *Copenhagen Climate Change Conference—December 2009 | UNFCCC*. https://unfccc.int/process-and-meetings/conferences/past-conferences/copenhagen-climate-change-conference-december-2009/copenhagen-climate-change-conference-december-2009

UNFCCC. (2015). *Paris Agreement*. https://unfccc.int/process-and-meetings/the-paris-agreement/the-paris-agreement

UNFCCC. (2021a). *Introduction to Climate Finance | UNFCCC*. https://unfccc.int/topics/climate-finance/the-big-picture/introduction-to-climate-finance

UNFCCC. (2021b). *The Glasgow Climate Pact – Key Outcomes from COP26 | UNFCCC*. https://unfccc.int/process-and-meetings/the-paris-agreement/the-glasgow-climate-pact-key-outcomes-from-cop26

UNFCCC. (2021c). *What is the Kyoto Protocol? | UNFCCC*. https://unfccc.int/kyoto_protocol

van Eck, N. J., & Waltman, L. (2014). Visualizing Bibliometric Networks. In Y. Ding, R. Rousseau, & D. Wolfram (Eds.), *Measuring Scholarly Impact: Methods and Practice* (pp. 285–320). Springer International Publishing. https://doi.org/10.1007/978-3-319-10377-8_13

Wang, C., Nie, P., Peng, D., & Li, Z. (2017). Green insurance subsidy for promoting clean production innovation. *Journal of Cleaner Production*, *148*, 111–117. https://doi.org/10.1016/j.jclepro.2017.01.145

Wang, H., & Bernell, D. (2013). Environmental Disclosure in China: An Examination of the Green Securities Policy. *Journal of Environment and Development*, *22*(4), 339–369. https://doi.org/10.1177/1070496513506905

Wang, M., Li, X., & Wang, S. (2021). Discovering research trends and opportunities of green finance and energy policy: A data-driven scientometric analysis. *Energy Policy*, *154*, 112295. https://doi.org/10.1016/j.enpol.2021.112295

World Green Building Council. (2022). *About Green Buildings*. https://www.worldgbc.org/about-green-building

Wylie, L., Sutton-Grier, A. E., & Moore, A. (2016). Keys to successful blue carbon projects: Lessons learned from global case studies. *Marine Policy*, *65*, 76–84. https://doi.org/10.1016/j.marpol.2015.12.020

Xueqing, J. (2021). *Fintech, green finance alliance to address investment woes*. https://www.chinadaily.com.cn/a/202106/19/WS60cd38d1a31024ad0baca1a9.html

Yi, X., Bai, C., Lyu, S., & Dai, L. (2021). The impacts of the COVID-19 pandemic on China's green bond market. *Finance Research Letters*. https://doi.org/10.1016/j.frl.2021.101948

Yin, X., Liu, H., Chen, Y., & Al-Hussein, M. (2019). Building information modelling for off-site construction: Review and future directions. *Automation in Construction*, *101*, 72–91. https://doi.org/10.1016/j.autcon.2019.01.010

Yip, A. W. H., & Bocken, N. M. P. (2018). Sustainable business model archetypes for the banking industry. *Journal of Cleaner Production*, *174*, 150–169. https://doi.org/10.1016/j.jclepro.2017.10.190

Yu, X., Mao, Y., Huang, D., Sun, Z., & Li, T. (2021). Mapping Global Research on Green Finance from 1989 to 2020: A Bibliometric Study. *Advances in Civil Engineering*, *2021*, e9934004. https://doi.org/10.1155/2021/9934004

Zerbib, O. D. (2019). The effect of pro-environmental preferences on bond prices: Evidence from green bonds. *Journal of Banking and Finance*, *98*, 39–60. https://doi.org/10.1016/j.jbankfin.2018.10.012

Zhang, B., Yang, Y., & Bi, J. (2011). Tracking the implementation of green credit policy in China: Top-down perspective and bottom-up reform. *Journal of Environmental Management*, *92*(4), 1321–1327. https://doi.org/10.1016/j.jenvman.2010.12.019

Zhang, D. (2021). How environmental performance affects firms' access to credit: Evidence from EU countries. *Journal of Cleaner Production*, *315*, 128294. https://doi.org/10.1016/j.jclepro.2021.128294

Zhang, D., Tong, Z., & Zheng, W. (2021). Does designed financial regulation policy work efficiently in pollution control? Evidence from manufacturing sector in China. *Journal of Cleaner Production*, *289*. https://doi.org/10.1016/j.jclepro.2020.125611

Zhang, D., Zhang, Z., & Managi, S. (2019). A bibliometric analysis on green finance: Current status, development, and future directions. *Finance Research Letters*, *29*, 425–430. https://doi.org/10.1016/j.frl.2019.02.003

Zheng, G.-W., Siddik, A. B., Masukujjaman, M., Fatema, N., & Alam, S. S. (2021). Green finance development in Bangladesh: The role of private commercial banks (PCBs). *Sustainability (Switzerland)*, *13*(2), 1–17. https://doi.org/10.3390/su13020795

Zhou, K., & Li, Y. (2019). Carbon finance and carbon market in China: Progress and challenges. *Journal of Cleaner Production*, *214*, 536–549. https://doi.org/10.1016/j.jclepro.2018.12.298