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# Periodizing Sustainable Finance Literature: A Comprehensive Bibliometric Review & Future Directions

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**Abstract**

Sustainable finance has emerged as a critical domain within financial research, driven by the growing global emphasis on climate action, environmental sustainability, and responsible economic development. This study presents a comprehensive bibliometric analysis of sustainable finance literature, tracing its evolution from the early environmental finance concepts to the current integrated frameworks incorporating environmental, social, and governance (ESG) considerations. By leveraging data from Scopus and Web of Science, the research identifies key trends, influential authors, and major thematic shifts in sustainable finance scholarship. Furthermore, the article proposes a periodization of sustainable finance research, shedding light on distinct developmental phases and projecting future directions for academic inquiry. The findings contribute to a deeper understanding of the field's trajectory, offering valuable insights for both researchers and policymakers engaged in sustainable economic transformation.

**Keywords:** bibliometric analysis, climate change, finance, research development, sustainability, sustainable finance

**JEL-codes:** B26, N20, Q56

## 1. Introduction

The field of sustainable finance (hereinafter:SF) is a bridge between economic growth, the financial sector and environmental protection (Andreeva et al., 2018; Rakić and Mitic, 2012) and therefore has a significant academic and societal role, contributing to sustainable development and environmental protection.

SF has emerged as a pivotal concept at the intersection of financial systems and sustainability imperatives, reflecting the global shift toward more responsible economic practices. Over the past decades, the term has evolved, encompassing diverse approaches like carbon finance, climate finance, environmental finance, and green finance – each representing a distinct stage in the field's maturation. The increasing urgency of climate change mitigation, resource

efficiency, and social responsibility has propelled SF into mainstream academic discourse and policy frameworks.

The relevance of SF is underscored by the escalating environmental challenges and the global commitment to achieving net-zero emissions. Financial systems are no longer evaluated solely on profitability but also on their contribution to broader environmental and social goals. Institutions, investors, and governments recognize that SF mechanisms are crucial for directing capital toward projects that mitigate climate change, promote social equity, and ensure long-term economic resilience. (Gyura, 2016) Moreover, regulatory frameworks, such as the European Green Deal and the UN Sustainable Development Goals (SDGs), are increasingly shaping financial markets. (Bartalos, 2023) These developments highlight the growing necessity for a robust understanding of sustainable finance's evolution and its role in fostering sustainable development.

Academic research plays a crucial role in this process, helping bridge the gap between theory and practice. The importance of scientific research on SF is that it is key to sustainable development and environmental protection, as measures and policies based on scientific findings can help transform financial systems to work more sustainably. The development of policy standards and their scientific validity go simultaneously, so research is most often not background research on this topic but is directly related to decision-making.

Despite the rapid growth of SF literature, gaps remain in understanding its historical progression, key thematic shifts, and influential contributors. This study distinguishes itself by offering a comprehensive bibliometric analysis that synthesizes past developments while projecting future research trajectories. Unlike traditional literature reviews, this approach provides a data-driven, systematic overview, mapping the intellectual structure of sustainable finance research (hereinafter:SFR).

The proposed periodization framework – delineating forerunners, early stages, and mature phases of SFR – introduces a novel lens for interpreting the field's evolution. By integrating bibliometric data with historical analysis, this study identifies not only dominant research themes but also emerging trends and underexplored areas, offering a roadmap for future inquiry.

The author's motivation for this study stems from a dual recognition: first, the accelerating importance of SF in global economic discourse; second, the fragmented nature of existing research, which often examines isolated aspects without a comprehensive historical or thematic synthesis. This research aims to fill that gap by providing a structured, data-backed analysis of the field's development. By shedding light on the academic landscape of sustainable finance, the author seeks to facilitate knowledge transfer between academia, policymakers, and practitioners, fostering more informed, effective financial strategies for sustainable development.

This study makes several significant contributions to the existing literature on SFR. It covers a wider time horizon, extending data collection until 7$^{th}$ April 2024, allowing for a more comprehensive assessment of recent trends. By integrating two major academic databases**,** Scopus and Web of Science, it ensures a broader and more representative bibliometric analysis. Additionally, it employs a broader and more refined keyword list, capturing a more extensive range of concepts and terminologies in sustainable finance. One of the key contributions of this study is the data-driven periodization of SFR, which identifies distinct historical phases shaped by institutional and market-driven transitions. Furthermore, it presents an updated research agenda, outlining future directions for scientific inquiry in green and sustainable finance.

To achieve these objectives, we developed a systematic and gradual research framework**,** guided by the following key research questions**:**

1. What patterns characterize the academic landscape of sustainable finance? How do trends in publication volume, conceptual developments, journal prominence, co-citation networks, and keyword co-occurrence influence the field's intellectual structure?
2. How does the geographical distribution of SFR vary across regions and economic classifications? What are the implications of disparities between developed and developing nations in terms of research output?
3. In what ways does the expansion of SF terminology correspond to the thematic progression of research in this field? How has the conceptual breadth of SF evolved, and what patterns emerge in the prioritization of these terms in research over time?
4. May we witness on our database that academic research on SF exhibit a temporal misalignment with policy and financial sector developments?
5. Can the progression of SFR be delineated into distinct historical stages? Which institutional transformations and market-driven advancements have been pivotal in directing its evolution? What chronological phases can be identified in the academic study of sustainable finance?
6. What are the most urgent and unexplored frontiers in SFR?

By addressing these research questions, this study aims to provide a structured and data-driven perspective on the development, current state, and future trajectory of SFR.

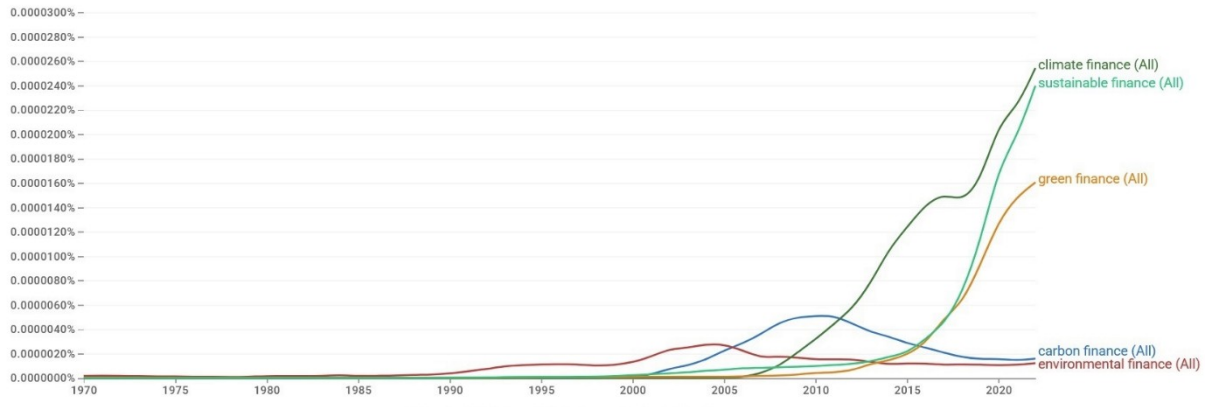
The paper unfolds in several stages to ensure a logical and comprehensive exploration of SFR. Following this introduction, the second section clarifies by definitions the differences between the terms related to SF. The third chapter discusses the Methodology and Database. It outlines the bibliometric techniques and data sources employed to construct the study's dataset. Next, the Findings and Results section presents a detailed analysis of publication trends, key authors, and thematic shifts, accompanied by visual representations of the evolving research landscape. The Periodization of Sustainable Finance Research section proposes a three-phase framework, contextualizing the field's development from early carbon finance concepts to mature, integrated SF models. Each phase is supported by bibliometric data, illustrating shifts in terminology, research focus, and academic influence. Finally, the paper concludes with a discussion on Future Directions, highlighting emerging research themes and underscoring the interdisciplinary nature of SF scholarship. The Limitations section acknowledges potential constraints, ensuring transparency and providing a foundation for future studies to build upon.

## 2. The Evolution of the Concept and Definition of Sustainable Finance

In this article, SF is used as the leading term, as it represents the broadest and most recent concept that integrates various approaches. There are two primary reasons for the diversity in terminology: (1) previous thematic focuses differed from the current refined understanding of the field's evolution, and (2) different stakeholders define SF through their own taxonomies. As a result, neither in the present nor retrospectively has a clear, comprehensive definition been established. The historical development of applied sustainable economic concepts follows a structured progression, with each stage corresponding to a distinct financial term that serves as a precursor to sustainable finance. In this section we follow the *United Nations*

*Environment Programme* (UNEP) study report (UNEP, 2015) and set the distinguishing definitive borders between the different terms related to sustainable finance. (Arezki, 2021)
The significance of this approach is reinforced by our Ngram chart (Figure 1), which clearly illustrates how different terms were prioritized during various periods. The data reveals that *environmental finance* was the dominant term in books between 1987 and 2001, after which *carbon finance* gained prominence – its rise began in 2000 and surpassed other terms by 2002. The use of *climate finance* intensified significantly after 2006, becoming the most frequently used term by 2010. During this period, *carbon finance* not only lost its relative prominence but also declined in absolute frequency. The rapid growth of the terms *green finance* and *sustainable finance* began in 2015, evolving in parallel until 2020, when *green finance* began to lose momentum compared to *sustainable finance*. Meanwhile, *climate finance* has continued to gain prominence, maintaining its strong presence in books throughout this period. It is important to highlight that Ngram relies on a different database than the one used in our bibliometric research. While Ngram analyzes books, our study primarily focuses on scientific journal articles. As a result, the trends observed in the Ngram data (Figure 1) may differ from the periodization presented in Chapter 5.

**Figure 1. Google Ngram: carbon finance, environmental finance, climate finance, green finance, sustainable finance, 1970-2022**




Note: We used for smoothing level 2.
Source: Google Books Ngram Viewer (https://books.google.com/ngrams)

**Carbon Finance**

The term *carbon finance* began to spread after the signing of the Kyoto Protocol. The World Bank Group among the first ones launched related research in the late 1990s. According to the World Bank Group, carbon finance "*is a generic term used for the revenue streams that can be generated by low-carbon projects and activities from the sale of their global greenhouse gas (GHG) emission reductions by sources, or GHG emission removals by sinks, or from trading in carbon credits"* (World Bank, 2018, p. xiii). This definition aligns with previous interpretations, such as: "*Carbon finance refers to the investment and financing activities associated with the low-carbon economy"* (Wu and Niu, 2024). Regarding its relation to other key concepts, Mosharrafa and Mahmuda define carbon finance as a subset of environmental finance: "*Carbon finance is a new branch of environmental finance which explores the financial propositions of a carbon controlled world".* (Mosharrafa and Mahmuda, 2014, p. 82.) As it targets solely mitigation this is the initial level of our terms.

**Climate Finance**

Adding adaptation to mitigation means the shift to the next phase: *the International Development Finance Club* (IDFC, 2022) categorizes climate finance into two main pillars: green energy and mitigation of greenhouse gases, and adaptation to climate change. According to the *United Nations Framework Convention on Climate Change* (UNFCCC), "*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 actions that will address climate change"* (UNFCCC, 2025). An earlier definition from the same source further elaborates: *"Climate finance aims at reducing emissions and enhancing sinks of greenhouse gases and aims at reducing vulnerability of, and maintaining and increasing the resilience of, human and ecological systems to negative climate change impacts"* (UNFCCC, 2018, p. 1.). The UNEP's report clarifies that climate finance is a subset of green finance. (Managi et al., 2022; UNEP, 2015)

**Green Finance**

IDFC's approach suggests that green finance is a broader category encompassing climate finance as well as financing for additional environmental objectives (IDFC, 2022), which is also underlined by *Shishlov and Philipp Censkowsky*. From a more practical approach it means that green finance aims to subordinate the financial system to the transition to a low-carbon and resource-efficient economy (Soundarrajan and Vivek, 2016; Sárvári, 2024). The distinguishing feature of *green finance* is the emphasis on environmental value in financial activities, setting it apart from non-green finance. The term is associated with green growth and lies at the intersection of environmental sustainability and economic development, requiring financial mechanisms to support capital investment in industries. (Noh 2018) As defined by the International Finance Corporation (IFC) (2016), g*reen finance broadly refers to "the financing of investments that provide environmental benefits"* (IFC, 2016, p. 3.). A narrower definition states that *"green finance refers to environment-oriented financial products or services, such as loans, credit cards, insurance, or bonds"* (UNESCAP, 2012, p. 1.). (Hajdu, Holczinger, 2024) Additionally, "*green finance is generally understood as finance supporting environmental—but not necessarily social—objectives that may include climate change, water and air pollution prevention, biodiversity preservation, etc."* (Shishlov and Censkowsky, 2022, p. 19.). Green finance incorporates two distinct approaches: *classic green finance*, which involves raising funds for climate and environmental projects, and *greening finance*, which focuses on improving financial risk management related to climate and environmental factors (Spinaci, 2021). Rashid and Uddin (2019) argues that green finance is a sub-aspect of sustainable finance.

**Environmental Finance**

Some scholars equate *environmental finance* with green finance. For example, the IFC systematically refers to environmental finance as green finance (IFC, 2016). However, other perspectives suggest a significant distinction: environmental finance is a broader concept as it supports environmental protection without necessarily promoting economic growth. According to Noh, e*nvironmental finance includes "all finance and investment regarding the ecological environment (air, water, soil, etc.)"* (Noh, 2018. p. 4). Additionally, environmental finance perceives environmental damage as a financial risk, thereby rejecting projects that cause or could cause environmental harm (Houska, 2022; Lazaro et al., 2023; Noh, 2018).

Originally, *environmental finance* referred to the application of environmental economics principles to finance and investment, as well as the use of financial derivatives for environmental protection (Sandor, 2017). Over time, its scope expanded due to advancements in environmental financial instruments, increasing environmental challenges, and the strengthening of environmental regulations. Cowan articulated this as follows: "*Environmental finance deals with the practical issues of paying for the level of environmental protection or an environmental initiative that a society has decided upon"* (Cowan, 1998. p. 3). The temporal evolution of these terms reveals notable differences in their adoption. (Lindenberg, 2014; Noh, 2019) According to Hu et al. (2022) and Figure 1. (Ngram), *environmental finance* was widely used earlier, already in the 1970s, with *green finance* gaining prominence only in the 2010s.

**Sustainable Finance**

As the broadest and most recent term, *sustainable finance* "*refers to the process of taking environmental, social, and governance (ESG) considerations into account when making investment decisions in the financial sector, leading to more long-term investments in sustainable economic activities and projects"* (European Commission, 2025). ESG considerations influence decision-making in both corporate and financial institutions (OECD, 2024). The primary goal is to increase "*long-term investments in sustainable economic activities and projects"* (Spinaci, 2021, p. 1.). Furthermore, SF encompasses all Sustainable Development Goals (SDGs) and governance aspects. The relationship between these financial terms is widely accepted: "*Climate finance is usually understood as a subset of green finance, which is, in turn, a subset of sustainable finance"* (Shishlov and Censkowsky, 2022, p. 19.).

In conclusion carbon finance is the financial term associated with mitigation efforts. Climate finance expands upon this by incorporating both mitigation and adaptation strategies. Green finance further broadens the scope by integrating mitigation, adaptation, and additional environmental aspects (e.g. pollution prevention and biodiversity conservation). Environmental finance builds upon these elements by including approaches that do not prioritize economic growth, in addition to the previously mentioned environmental components. (Somogyi-Farkas, 2025) Finally, SF represents the most comprehensive stage, encompassing all prior aspects along with social and governance considerations, making it the broadest financial framework within sustainable economics.

## 3. Methodology and database

To present the literature of sustainable finance, we conducted a bibliometric analysis. The final sample was obtained through a multi-step process, with data collection as the first step. We used the two largest international scientific platforms, the Scopus and Web of Science (WoS) databases, to search for relevant sources, ensuring a broader collection, similar to Singhania et al. (2023). Since *sustainable finance* is a broad concept encompassing multiple topics, we conducted searches using several relevant keywords, which are displayed under Figure 2. The Scopus was filtered by Keywords, but WoS could only filter by Author Keywords and Keyword Plus, and we decided on the latter.

We did not apply inclusion criteria such as language, document type, or source type, and in this way, we collected 1,488 items from Scopus and 4,303 items from WoS, which resulted far the widest corpus compared to the previous bibliometric analyses (Singhania et al, 2023 provides a summary of previous literature reviews). The search results were downloaded in BibTeX format from both databases on April 7, 2024. However, since there was an overlap

between the two databases, the next step was their unification. This process was programmed in RStudio, where we identified 1,164 duplicates, then refined the merged database using Excel.

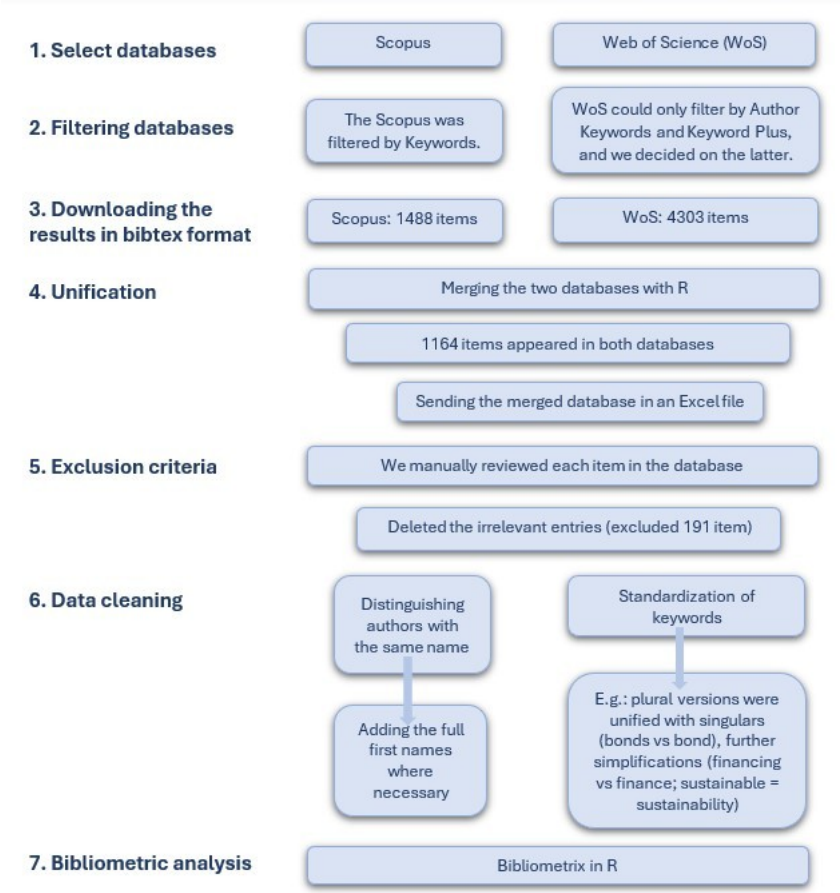
We manually reviewed each item in this database and deleted 191 irrelevant entries where keywords matched only formally but belonged to different scientific fields (e.g., optics, astronomy, chemistry). Examples include articles that were get in our downloads due to the Green Bank Observatory, which is only in name related to sustainable finance, but targets astronomers. We also removed retracted publications from our collection. As a result, our final sample consisted of 4,436 items.

Since the file generated by R only contained authors' last names and first name initials, we had to ensure that individuals with the same initials, but different identities were correctly distinguished during the analysis. Therefore, we reviewed the entire list and manually corrected this issue by adding the full first names where necessary.

The last step – also done manually – was consolidating different grammatical forms of identical expressions in the keywords (e.g., green finance = green financing, investments = investment, etc.).

The final database was analyzed using the Bibliometrix package in R (Aria & Cuccurullo, 2017), and the results are presented in the following chapter.

**Figure 2. Research process adopted in the study**




Source: Author's compilation

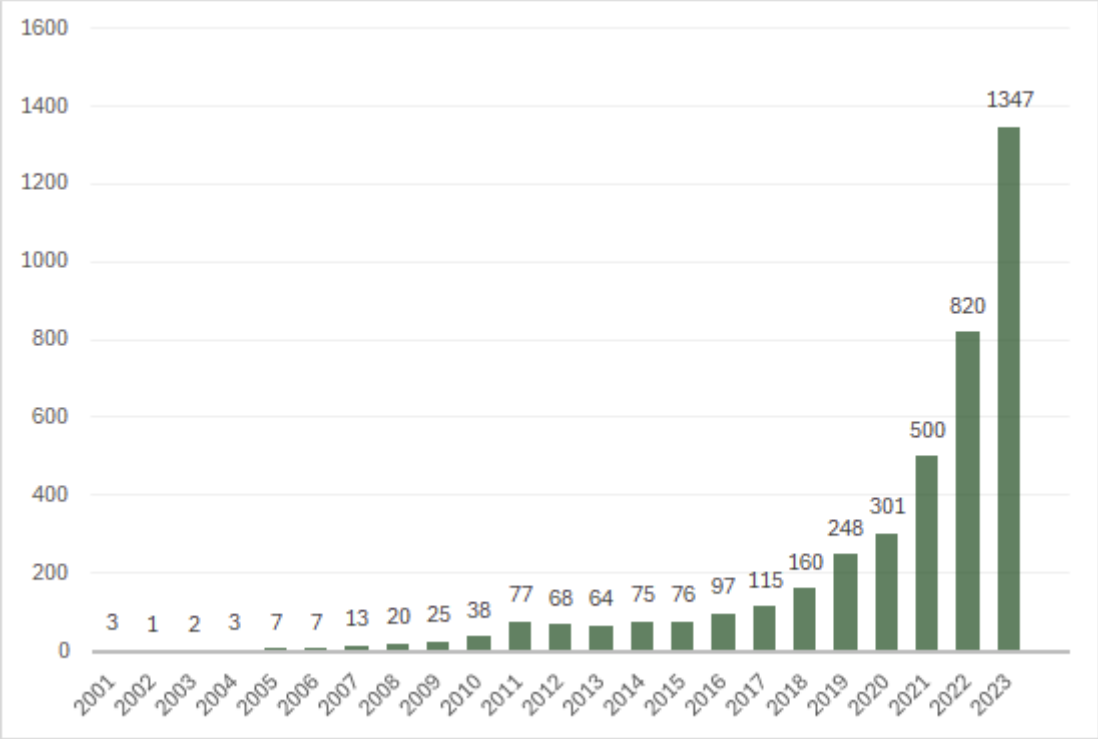
Note: At the step (2.) filtering databases we did not have inclusion criteria as Language, Document Type, Source type, etc. and we used the following keywords: "carbon financ*" OR "carbon Invest*" OR "clear energy stock*" OR "climate bank*" OR "climate financ*" OR "climate fund*" OR "climate Invest*" OR "environmental financ*" OR "green bank*" OR "green bond*" OR "green credit*" OR "green financ*" OR "green fund*" OR "green insur*" OR "green invest*" OR "green loan*" OR "green mandat*" OR "green portfoli*" OR "green public financ*" OR "green risk*" OR "low-carbon financ*" OR "low-carbon invest*" OR "pro-environmental invest*" OR "renewable energy financ*" OR "sustainable bank*" OR "sustainable financ*" OR "sustainable investm*" OR "weather derivativ*"

## 4. Findings and results

The research focuses on scientific production related to SF, from its initial milestones (the first article using such a keyword is from 2001) to the latest developments (since 2024 is not a complete year in our database, we refer to that only when it is relevant). Analyzing the dataset of 4,436 records reveals the evolution of literature, research trends, and opportunities for further investigation.

Despite our broader time horizon compared to typical bibliometric studies on sustainable finance, the annual growth rate of 23.27% and the average document age of 4.46 years indicate the rapid advancement of SFR in recent years. It is visible on Figure 3 which demonstrates the number of papers published in each year.

**Figure 3. Number of publications per year**




Source: Authors' own compilation using Bibliometric R-package

A clear upward trend in publications is evident throughout the sample period. After the pioneering papers appeared in 2001, our results show a limited number of publications during the period from 2001 to 2009.

After the initial publications, scientific output on sustainable financing has consistently increased. The first significant rise in publications occurred after the establishment of the Green Climate Fund (GCF) in 2010, but this growth plateaued until 2015. Notably, in contrast to the slow and steady growth before 2015, the number of relevant publications has surged sharply since then, indicating a substantial increase in academic interest in SF following the adoption of the Paris Agreement. (Çuçi, 2024) However, a noticeable structural shift in the growth pattern emerged after 2019, when António Guterres, the secretary-general of the United Nations hosted the Climate Action Summit, which heightened ambitions to accelerate the implementation of the Paris Agreement. This sharp rise suggests that sustainable finance has become a significant topic among academics, driven by the global momentum of investment in SF. These trends align with the conclusions drawn by Akomea-Frimpong et al. (2022), further supporting the notion that SF has emerged as a critical research domain within the broader discourse on sustainable development and climate policy.

Interestingly, the average citation count per document is 17.55, suggesting the selected documents are of high quality and impact, reinforcing rather than diminishing the corpus due to the extended timeframe.

The corpus primarily comprises reviewed articles (including early access articles) at 3,965, followed by proceedings papers (266), reviews (180), editorial materials (24), and others (1). With 7,596 author appearances and a collaboration index of 2.94, the data highlights significant increases in collaboration among countries and authors. Table 1 below provides a summary of the corpus's general characteristics.

**Table 1. General characteristics of Corpus**

| Description | Results |
|---|---|
| MAIN INFORMATION ABOUT DATA | |
| Timespan | 2001:2024 |
| Sources (Journals, Books, etc) | 1173 |
| Documents | 4436 |
| Annual Growth Rate % | 23,27 |
| Document Average Age | 4,46 |
| Average citations per doc | 17,55 |
| References | 132504 |
| DOCUMENT CONTENTS | |
| Keywords Plus (ID) | 3850 |
| Author's Keywords (DE) | 9626 |
| AUTHORS | |
| Authors | 7596 |
| Authors of single-authored docs | 578 |
| AUTHORS COLLABORATION | |
| Single-authored docs | 671 |
| Co-Authors per Doc | 2,94 |
| International co-authorships % | 30,59 |
| DOCUMENT TYPES | |
| article | 3673 |
| article article | 4 |
| article; book chapter | 1 |
| article; data paper | 5 |
| article; early access | 282 |
| article; proceedings paper | 19 |
| book review | 2 |
| correction | 1 |
| editorial material | 22 |
| editorial material; early access | 2 |
| proceedings paper | 247 |
| review | 167 |
| review; book chapter | 1 |
| review; early access | 10 |

Source: Authors' own compilation using Bibliometric R-package

### 4.1 About the Sources

The Biblioshiny package understands the term 'Sources' to mean 'journals' found in the database, therefore we use the terms 'Sources' and 'journals' as synonyms during the analysis. A total of 1,173 different sources were included in our database between, but most of the journals published only one or few papers about the analysed topic. Each of the top 12 most published journals had more than 50 articles published during this period, with more than 100 articles published in the top 6. According to Bradford's Law, the top 10 journals are

represented in the first zone. Prominently, the most relevant source according to the number of published articles is *Sustainability* with 377 articles (see Table 2).
If we look at the number of citations of the articles published in the journals, *Sustainability* is only in second place and the *Journal of Cleaner Production* is by far the top with a total citation of 8574 and h-index of 46. In comparison, the h-index of the first ten ranked journals according to the h-index is higher than 22. However, the m-index, which also controls the number of years that have passed since the first publication of the journals on the topic, is the highest for *Sustainability*. It is clear that in recent years *Sustainability* has dominated SF publications (see Tabel 2). In terms of citations, the *Frontiers in Environmental Science* seems to be an outlier and not decisive, because it ranks only 48$^{th}$ in terms of the number of local citations, although it publishes relatively much on the subject. Within the corpus, *Climate Policy* and *Journal of Sustainable Finance & Investment* played not a central role based on local citations (see Tabel 2).

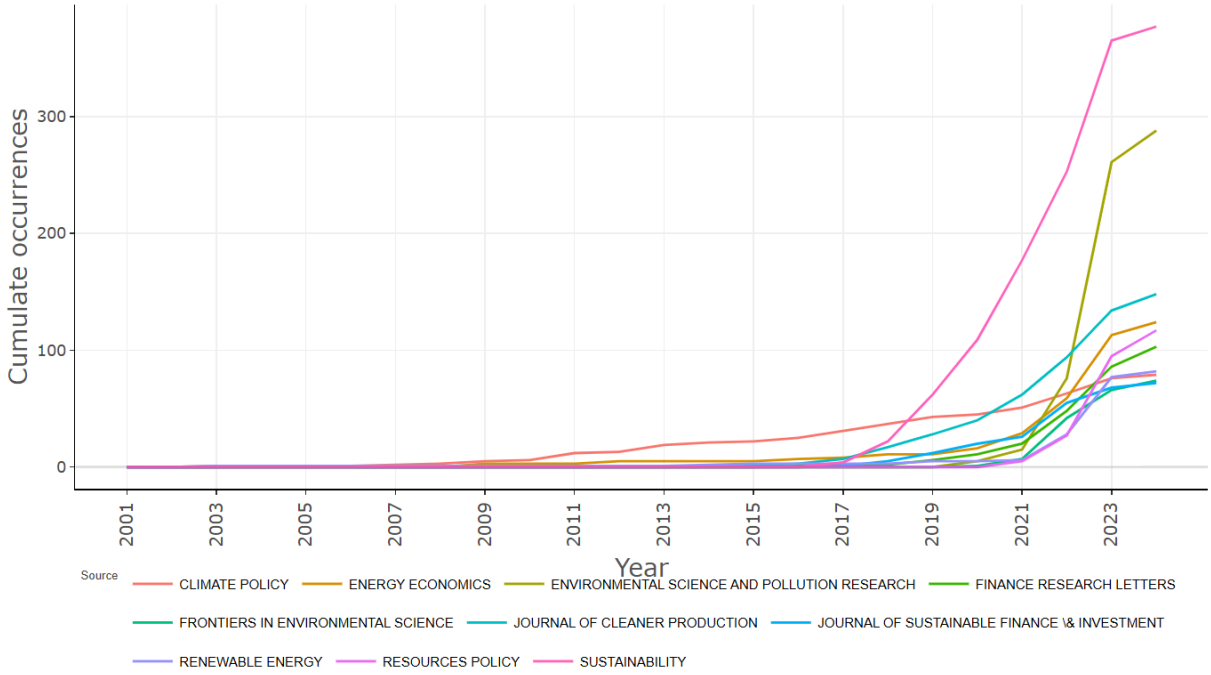
**Table 2. Main characteristics of the journals are in the top 10 according to the number of published articles since 2001**

| Journals (Sources) | Number of Articles since 2001 | Number of Local Citations since 2001 | h-index | m-index | Ranking according to citation |
|---|---|---|---|---|---|
| Sustainability | 377 | 4987 | 37 | 4,625 | 4 |
| Environmental Science and Pollution Research | 288 | 5291 | 34 | 6,8 | 3 |
| Journal of Cleaner Production | 148 | 8574 | 46 | 4,182 | 1 |
| Energy Economics | 124 | 6554 | 36 | 2,25 | 2 |
| Resources Policy | 117 | 2905 | 28 | 7 | 7 |
| Finance Research Letters | 103 | 3141 | 24 | 2,667 | 6 |
| Renewable Energy | 82 | 2295 | 28 | 1,273 | 12 |
| Climate Policy | 79 | 1039 | 23 | 1,045 | 24 |
| Frontiers in Environmental Science | 74 | 533 | 12 | 2,4 | 48 |
| Journal of Sustainable Finance & Investment | 72 | 1038 | 19 | 2,375 | 25 |

*Note: Own edition based on analysis of Sources prepared by Biblioshiny package*
Source: Authors' own compilation using Bibliometric R-package

*Sustainability* stands out from other journals because it has published the most cumulatively since 2019. However, since 2021, we have seen rapid growth in the publication of other journals in SFR, such as the *Journal of Cleaner Production,* the *Environmental Science and Pollution Research* and the *Energy Economics* among others. However, the pioneer was *Climate Policy,* which journal discovered the importance of the topic as early as 2011. Since then, it has shown a permanent but slowly increasing publishing trend although if we look at the journal's m-index, it does so far from being the most influential. The recent newcomer is *Environmental Science and Pollution Research,* which published numerically 261 articles in 2023 and 288 articles in 2024 according to our database with the highest m-index (see Table 2 and Figure 4).

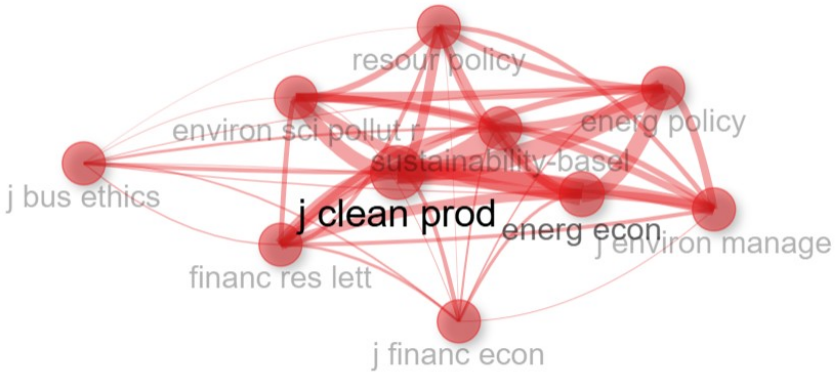
**Figure 4. Annual sources' production over time by top 10 journals, 2001-2024**




Source: Authors' own compilation using Bibliometric R-package

If we analyse co-citation network of the top 10 journals with the settings at least 20 citations received from each other, *Journal of Financial Economics*, *Journal of Business Ethics* and *Journal of Environmental Management* will be put on the map. Overall, it is also clear that the *Journal of Cleaner Production* plays a leading role and *Energy Economics* is the second most important journal (see Figure 5). Although, because of the highest m-index, *Environmental Science and Pollution Research* plays the most central role recently.

**Figure 5. Co-citation network between Sources, 2001-2024**




Notes: number of nodes 10, minimum number of edges 20
Source: Authors' own compilation using Bibliometric R-package

### 4.2 About the Authors

Among the authors in our database, Taghizadeh-Hesary Farhad, who was by far the most productive, with 35 articles on the SF topic. This author performs significantly in terms of both local and total citations, as he received the most citations on both lists in our database. (see Table 3). He also has by far the highest h-index in the corpus. In addition to him, we must also highlight Naeem Muhammad Abubakr and Umar Muhammad, who are of great significance in the field of SFR and have an impact on research in other areas as well. Others, like Zerbib O, Flammer C and Tang Dragon Yongjun play important role within our database but they are not so significant authors outside according to their total citations.

**Table 3. The first 10 most local cited authors according to the number of the local and total citations, the affiliation, the city and the country, 2001-2024**

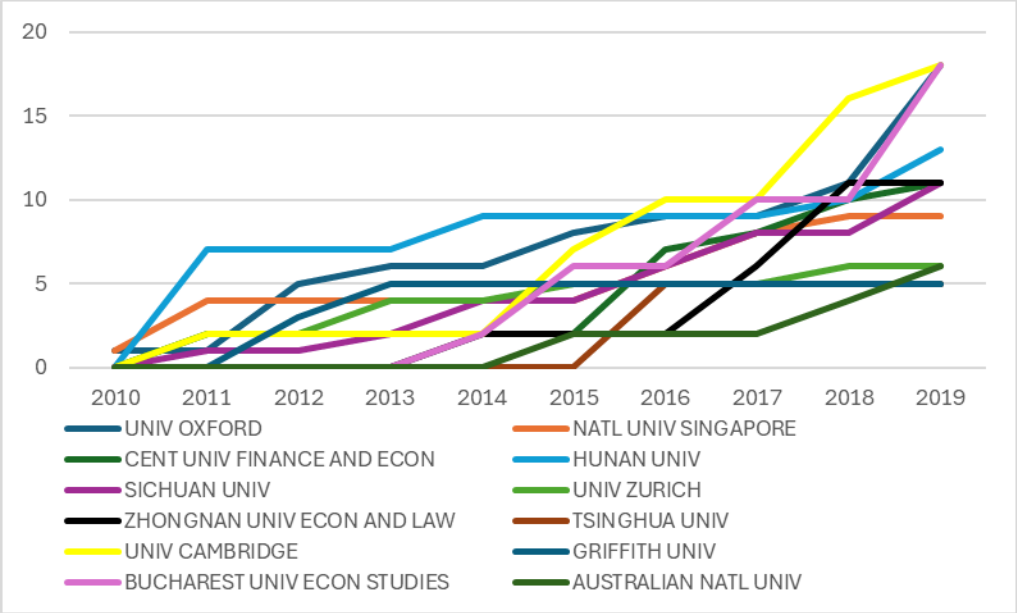
| Author | Local Citation | Total Citation | Affiliation | City, Country |
|---|---|---|---|---|
| Taghizadeh-Hesary F | 608 | 2575 | Tokai Univ | Kanagawa, Japan |
| Yoshino N | 387 | 799 | Keio Univ | Tokio, Japan |
| Zerbib O | 298 | 445 | Tilburg Univ | Tilburg, Netherlands |
| Naeem Muhammad Abubakr | 289 | 1208 | United Arab Emirates Univ | Arab Emirates |
| Flammer C | 255 | 412 | Boston Univ | Boston, Usa |
| Tang Dragon Yongjun | 234 | 322 | Univ Hong Kong | Hong Kong, China |
| Zhang Yupu | 234 | 322 | Univ Hong Kong | Hong Kong, China |
| Umar Muhammad | 188 | 1405 | Wuchang Univ Technol | Wuchan, China |
| Reboredo J | 186 | 709 | Univ Santiago De Compostela | Santiago De Compostela, Spain |

| | | | | |
|---|---|---|---|---|
| Ugolini A | 186 | 393 | Univ Estado Rio De Janeiro | Rio De Janeiro, Brazil |

Source: Authors' own compilation using Bibliometric R-package

Between 2010 and 2019, the picture was more varied in the list of universities whose authors received the most local citations. In this period, in addition to universities in Chinese cities, we can also find universities among else from Oxford, Cambridge, Zurich, and Bucharest (see Figure 6). Based on the corpus, China has clearly dominated this market since 2019, with only the University Oxford and the Lebanese Amer University in the first 10 places besides Chinese universities. Wuhan University ranks first in the latest year. We must note, however, that our results are somewhat distorted, because they were published from several different institutes of Wuhan University, which we now see combined in the sample, which is why this university takes first place in 2023 (Economics and Management School, Institute of Regional and Urban-Rural Development, Research Institute of Environmental Law). Of course, this distortion also exists in the case of other universities, because this problem cannot be handled with such a large number of elements.

**Figure 6. Affiliations' production over time, 2010-2019**




Source: Authors' own compilation using Bibliometric R-package

China's rise in the field of SFR is also demonstrated by the fact that it leads the ranking by far among other countries, both in Single Country Publications (SCP) and in Multiple Country Publications (MCP). Nearly 40% of articles on the topic have Chinese interests. However, China's disadvantage in terms of Average Article Citations is a good indication that Chinese authors have made progress in recent years. So far, several countries have surpassed China in this indicator, with Lebanon in first place in our database.

**Figure 7. Co-citation network among countries, 2001-2024**

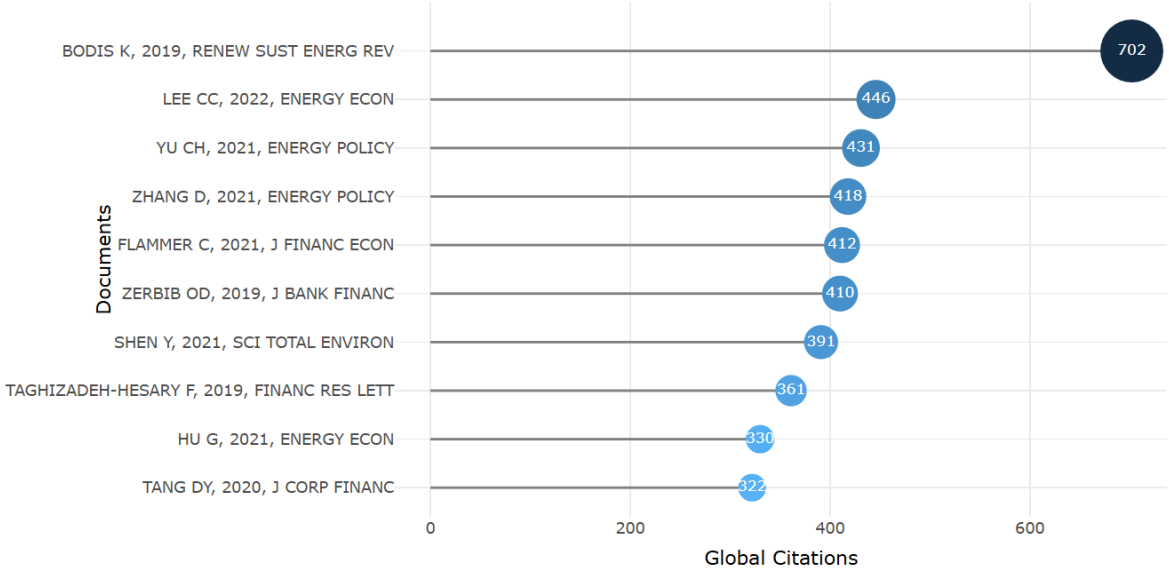

Source: Authors' own compilation using Bibliometric R-package

According to the co-citation graph among countries we can see that China is the bridge in the international research about SF topic, having joint research with many countries, prominent among them Pakistan, UK, Malaysia, the USA and Australia, but of all of them, the strongest connection is between Pakistan and China. In the world, many developing countries are not represented in SFR, even though they are the most affected, and there is a great need for global hubs and knowledge transfer (see Figure 7).

### 4.3 About the Documents

The top list of publications based on the most global cited journal articles mostly coincide with the top list of journals based on total citations (see Figure 8). Notable exception is the *Journal of Corporate Finance* and the *Science of the Total Environment* because these journals are not in the first 20 journals according to the total citations. Remarkable furthermore that the first 15 places only include such articles that were published in a journal by ELSEVIER. The list does not differ significantly even if we look at the ranking of the articles based on the total citations per year (citations received by a selected article from any source).

**Figure 8. The 10 most global cited documents in our database, 2001-2024**



Source: Authors' own compilation using Bibliometric R-package

If we investigate the local citation (citations received by a reference article internally to the database) of the articles, the picture is heterogenous, because some of the list cited by many of the articles from our database, but others have received no citation from documents included in our collection. We can see in the list based on local and global references that the documents in the first 15 places only partially overlap (see Table A.1). It follows that some of the globally most cited articles in our database are not exceptionally part of the typical SFR but leak into other important areas.

### 4.4 Words

The articles in our database were selected based on the keywords we provided (see in detail the 3. Methodology and database section). In this section we review the statistics of our database for keywords that are assigned to the article by the authors themselves and for Keywords Plus, which are generated based on the reference list from cited titles used by the study. According to Table 4, we cannot experience an overlap between the top 10 keywords used by the authors and the Keywords Plus column.

**Table 4. The top 10 author's keywords and Keywords Pluses according to the number of occurrences in our database**

| Author's keywords | Occurrences | Keywords Plus | Occurrences |
|---|---|---|---|
| green finance | 1020 | impact | 506 |
| green bond | 544 | performance | 426 |
| sustainable finance | 408 | investment | 304 |
| climate finance | 375 | economic-growth | 254 |
| sustainability | 329 | policy | 247 |
| green investment | 276 | innovation | 246 |
| climate change | 259 | risk | 229 |
| China | 218 | growth | 222 |
| sustainable development | 213 | management | 217 |
| sustainable investment | 196 | energy | 194 |

Source: Authors' own compilation using Bibliometric R-package

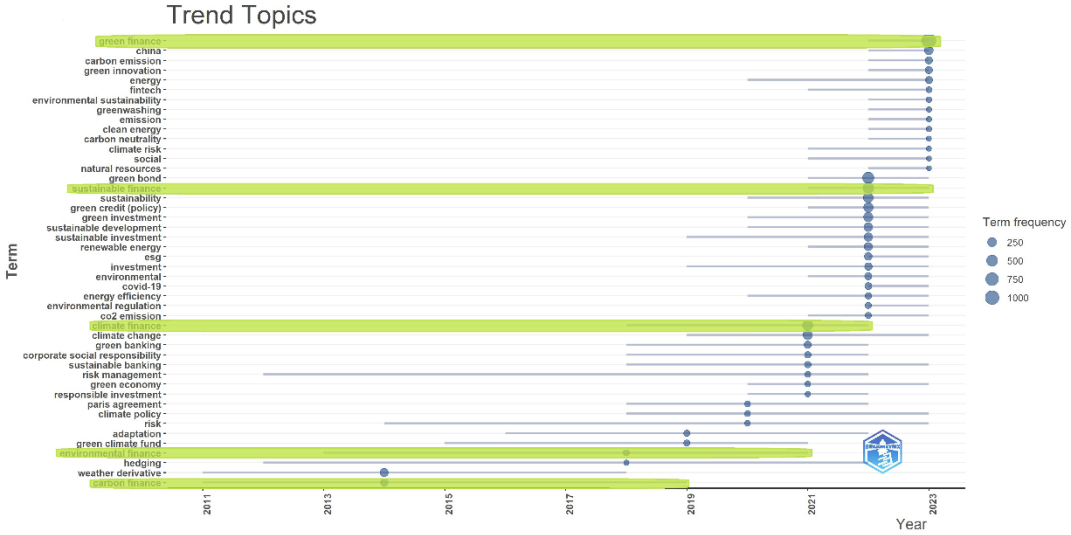
Meanwhile the Author Keywords are chosen manually by the authors to reflect the core focus of their research, Keywords Plus are generated automatically by bibliographic databases from frequently occurring words in article titles and references. The first ones tend to be specific, technical, and precise, the latter ones tend to be broader and more general. It may mean that Keywords Plus may not be fully representative of how researchers describe their work, leading to potential retrieval biases in literature searches. An other potential implication might be that

the field is evolving, and Keywords Plus has not yet adapted to new terminology trends. This observation strengthened our decision to rely on Authors' keywords in our analysis instead of Keyword Plus.

## 5. The Evolution and Periodization of Sustainable Finance Research

This study analyzes trend topics (Figure 9) using authors' keywords in Biblioshiny. Based on this trend analysis and its alignment with the evolution of the concept and definition of SF (as discussed in Chapter 2), we propose a periodization of SFR. The following sections present our findings; however, before sharing the details, it is important to emphasize a key observation: scientific research in these areas has generally progressed at a slower pace, often trailing behind regulatory developments and market innovations. For instance, although the EU ETS was established in 2005, studies on carbon finance did not reach peak academic interest until 2014, highlighting the delayed uptake of climate-related financial research.

**Figure 9. Trend topics according to the authors' keywords, 2010-2024**




*Note*: Settings: word minimum frequency 30, number of words per year 15
*Source:* Authors' own compilation and editing using Bibliometrix R-package.

This classification of SFR into distinct phases represents a new contribution to the literature (see Figure 10), building upon earlier frameworks while offering a structured historical perspective *(Akomea-Frimpong et al, 2022; Bhatnagar and Sharma, 2022; Caré and Weber, 2023; Muchiri et al., 2022; Sárvári, 2024; Zhang et al., 2019*). To create this periodization, we mainly followed our results in Figure 9, which show the median years of certain topics as well.

1. The Forerunners of Sustainable Finance Research (1970s–2010)

The first phase of SFR, termed **The Forerunners of Sustainable Finance Research**, spans from the 1970s to 2010 and is divided into two distinct sub-periods.

1.1. The first sub-period, **Theoretical Background (1970s–1987)**, marks the beginning of theoretical advancements in environmental economics, where economic tools and models were first applied to sustainability-related challenges. A key institutional milestone of this period was the Brundtland Commission, which laid the foundation

for sustainable development principles. In terms of financial market innovations, microfinance emerged as a significant tool, enabling financial services for disadvantaged populations through market-based enterprises without subsidies, making it an early predecessor of sustainable finance.

1.2. The second sub-period, the **Emergence of Sustainable Financial Instruments and Research (1988–2010)**, saw significant institutional and market developments. A milestone in linking economic activity, pollution, and climate change was the establishment of the Intergovernmental Panel on Climate Change (IPCC) in 1988 by the World Meteorological Organization (WMO) with UNEP's support. The IPCC's reports spurred renewed research interest in renewable energy financing and climate-related investments. The first scientific analysis of the green economy appeared in the late 1980s (*Pearce et al., 1989*), with *Blueprint for a Green Economy* introducing the impact of industrialization on environmental degradation. This work is regarded as a precursor to scientific research on sustainable finance, though the term was not spread yet.

A defining institutional milestone of this period was the 1992 Earth Summit, which initiated a paradigm shift in the financial sector *(Gerster, 2012)*, setting the stage for SF (*Lazaro et al., 2023*). Also Lazaro et al. concluded that "starting point in 1992 for transforming finance into SF was the goals for mitigating climate change and achieving sustainable development" (Lazaro et al. 2023 p. 3.) Another significant institutional and market development was the adoption of the Kyoto Protocol in 1997, introducing emissions trading as a regulatory mechanism. (Leitão and Balogh, 2020; Muth, 2023; Németh-Durkó, 2020) Following a complex ratification process, it came into force in 2005, coinciding with the launch of the EU Emissions Trading System (EU ETS), the world's first international carbon market. During the 1990s, the Global Environment Facility (GEF), established prior to the 1992 Rio Earth Summit, was entrusted with operating the financial mechanism (*UNEP, 2025*). Additionally, the UNFCCC and the Kyoto Protocol introduced market-based mechanisms to assist nations in fulfilling their climate commitments (*Lazaro et al., 2023*).

From a market perspective, the concept of eco-efficiency gained prominence in the early 1990s, emphasizing how businesses could align environmental sustainability with economic efficiency. Concurrently, the notion of investor responsibility led to increased interest in sustainable investments, integrating environmental, social, and governance (ESG) factors into financial decision-making.

A major financial innovation of this period was the green bond. On July 5, 2007, the European Investment Bank (EIB) issued the Climate Awareness Bond (CAB), recognized as the world's first green bond. Shortly thereafter, in 2008, the World Bank followed with its first official green bond issuance. The issuance of green bonds accelerated rapidly in subsequent years. Similar to the rise of sustainable investments, the emergence of green bonds and other financial instruments significantly reshaped the business and financial landscape, drawing increasing attention from the academic community. (Daszyńska-Żygadło et al., 2018)

2. Early Sustainable Finance Research (2010–2021)

The second phase of SFR, termed **Early Sustainable Finance Research**, spanned from **2010 to 2019** and can be further divided into three sub-periods which already appear on Figure 9.

2.1. The **Carbon Finance Period (2010-2015)** – Marked by the establishment of the Green Climate Fund (GCF), created by 194 countries to financially support developing nations in mitigating GHG emissions and adapting to climate change. This period saw increasing academic interest in financial sector involvement and innovation in financial instruments to address climate risks. The creation of the Green Climate Fund significantly increased academic interest in research focused on the financial sector's role in climate action and the innovation of financial instruments aimed at regulating and mitigating climate change and promoting adaptation. This period also saw heightened attention on weather derivatives, which became a focal point of market-based climate risk management strategies. Additionally, this phase included research on institutional changes in emissions trading from previous periods and initiated risk analysis and risk management studies, which continued across multiple research phases.

2.2. **The Environmental Finance Period (2015–2019)** – This phase was marked by the adoption of the Paris Agreement and the UN Sustainable Development Goals (SDGs) in 2015, which significantly influenced the financial sector's role in addressing climate change. Since the mid-2010s, the study of the relationship between climate change and finance has gained increasing academic attention. The Paris Agreement has further underscored the necessity for financial institutions to mitigate climate change impacts and fund adaptation efforts. As a result, sustainable financial products have emerged as crucial instruments to counteract environmental and climate risks. Research has highlighted the Paris Agreement's market implications, such as Pham et al. (2019), who found that the agreement increased stock return risks in polluting industries. Nearly all countries have pledged to contribute to climate change mitigation, fostering the development of regulatory frameworks that encourage financial actors to engage in sustainable practices. The pursuit of ambitious sustainability goals, coupled with the increasing demand for financial resources, has significantly heightened interest in SF among policymakers. This has also led to a substantial rise in scientific publications on the topic since 2015. A defining market instrument of this period is the sovereign green bond, with Poland issuing the first one in 2016, along with the emergence of sustainability-linked loans in 2017. Research during this phase extensively explores the concept of adaptation, which is formally classified under climate finance. Additionally, this period includes a scientific examination of the significance of the Green Climate Fund, while studies on climate risk assessment and management continue to evolve.

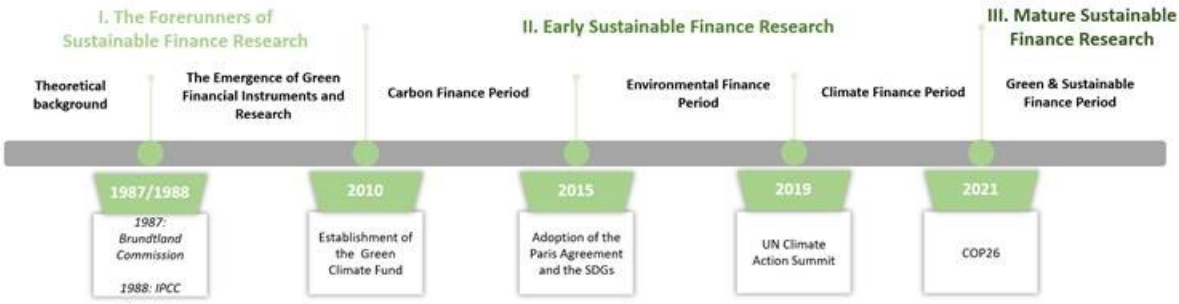
2.3. **The Climate Finance Period (2019–2021)** – The 2019 Climate Summit (UN Climate Action Summit, September 2019) marks the beginning of this period. The event was initiated and chaired by UN Secretary-General António Guterres, reinforcing the urgency of accelerating action to implement the Paris Agreement. Several countries announced more ambitious emission reduction commitments, further stimulating scientific research in this field. Another key institutional milestone of this period is the adoption of the EU Taxonomy. The Taxonomy Regulation, which became legally

binding in July 2020, establishes a general framework for classifying sustainable activities. In April 2021, the European Commission introduced the first set of criteria, which officially came into effect in December 2021. Additionally, the COP26 Climate Conference (Glasgow, November 2021) played a significant role in shaping climate policies, as several countries announced more ambitious emission reduction targets. The conference also led to the adoption of the Glasgow Climate Pact, which aims to phase out fossil fuels and mitigate the impacts of climate change. Research in this period focuses extensively on the expansion of responsible investment, a trend closely linked to the EU's economic recovery package (NextGenerationEU), which financed significant green investments. Key academic topics during this phase include corporate social responsibility (CSR) and risk management, with the median year for risk management research being 2021. Additionally, this period examines the impacts of the Paris Agreement in greater depth. A crucial factor shaping this relatively short period on a global scale was the COVID-19 pandemic, which led to a slowdown in economic activity worldwide and a temporary reduction in greenhouse gas emissions.

3. Mature Sustainable Finance Research (2021–Present)

This period encompasses green and sustainable finance research, and although there is a conceptual difference between the two, they are evolving in synchrony in the scientific research space: the median year for SFR is 2022, the median year for green finance research is 2023. Building on previous research and policy decisions, a mature and comprehensive body of scientific studies is now emerging, covering a broader range of topics. These include the analysis of green financial products and markets, the evaluation of ESG indicators' effectiveness and relevance, and the growing interest in the intersection of green technologies and financial innovation – particularly in areas such as renewable energy, energy storage, and smart cities. (Sárvári, 2021) Additionally, climate risk analysis has gained prominence, with the financial sector increasingly prioritizing risk assessment and preparedness for climate change impacts. Another key area of focus is green finance and social inclusion, exploring how SF can promote social justice and ensure that its benefits are equitably distributed across all sectors of society. Key institutional milestones of this period include COP26 (Glasgow, November 1–12, 2021) and COP27 (Sharm El-Sheikh, November 6–18, 2022). The latter focused particularly on adaptation and climate finance, with an emphasis on supporting developing countries in addressing the impacts of climate change. Additionally, the UN Biodiversity Conference (COP15, Kunming, December 2022) resulted in the adoption of a new global biodiversity framework, setting targets for nature conservation through 2030. Scientific research in this period places a strong emphasis on green bonds, green loans, and sustainable investments, particularly in areas such as energy efficiency, carbon and $CO_2$ emissions reduction, and renewable energy sources. This phase also sees the increased academic focus on regulatory aspects, including the analysis of greenwashing practices and their implications.

**Figure 10. The Finance Research**




*Source:* Authors' own compilation

## 6. Possible future directions for sustainable finance research

Although it is impossible to outline the future directions of SFR, given the considerable uncertainties, it is possible to list the areas where there is currently the greatest demand for information and which are the emerging themes in the research portfolio. Of course, there will be significant variations later on and, as seen in 2022–2023, geopolitical events will shape the priorities for SFR. Regardless of the preferences of the main economics and finance journals, a surge in publications is currently expected in the coming years along the following major themes.

Since SF is essentially a financial issue, studying it from a financial perspective and using the associated methodology will certainly be a worthwhile scientific output. These include green bonds, green risk management and green governance.

A deeper analysis of SF from the perspective of developing countries is expected to be a major focus. These results may directly shape the actions of regulators and decision-makers in aligning different policy objectives. (Petera et al., 2021; Baranyai et al., 2025)

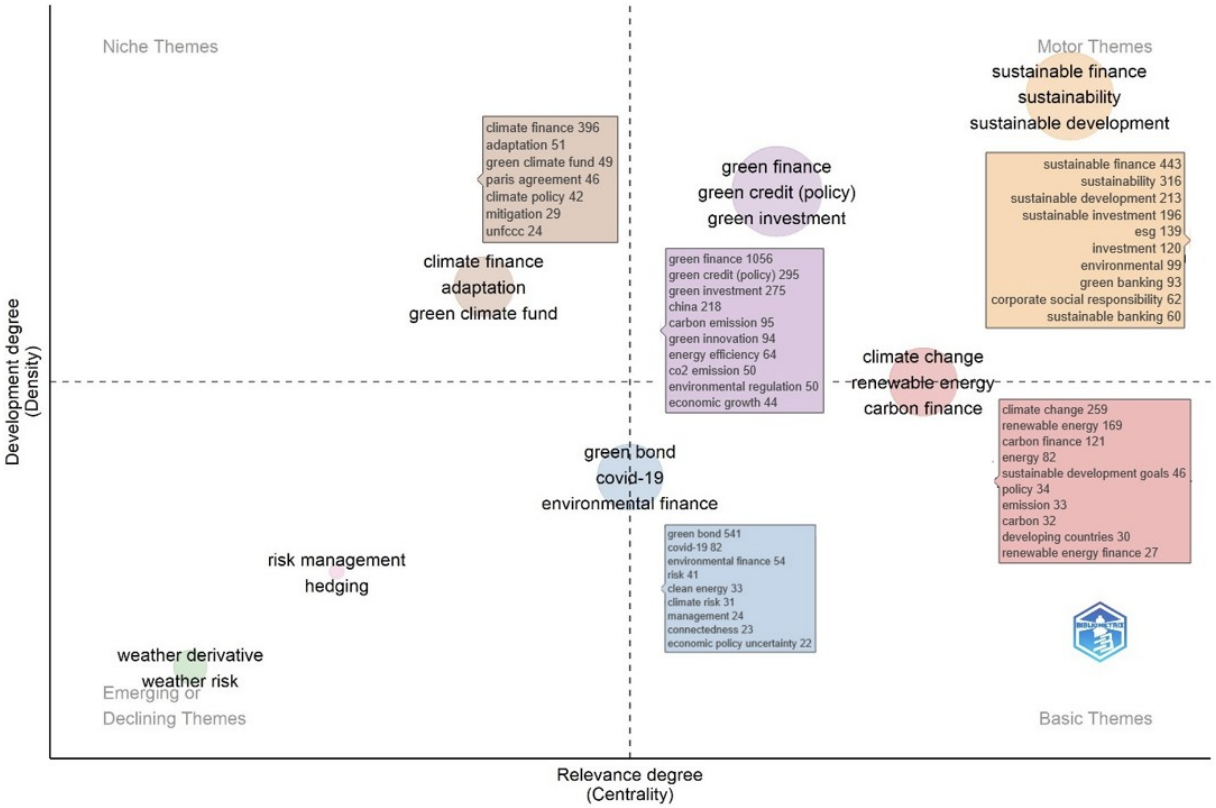
An important difference between SF and standard financial issues is that the former is essentially policy-driven. In a rapidly changing international economic and political environment, new issues are therefore likely to arise in this area (Zhang, 2019).

Climate change could have a significant impact on financial markets, including both risks and opportunities. The analysis of such impacts and research on the adaptation strategies of financial actors could be a priority topic.

Further refinement and development of ESG factors may be necessary in order to better measure and assess the sustainability of companies and investments. As the ESG criteria are becoming more widespread in the market, it is developing a strong community of interest as it is further fine-tuned, and this could also stimulate scientific research.

These are all align with our observations gained from the thematic map according to Authors' keywords (Figure 11).

**Figure 11. Thematic map according to the authors' keywords**




*Note*: Settings: minimum cluster frequency: 5; number of labels: 3; number of words 400
*Source:* Authors' own compilation using Bibliometric R-package.

The thematic map serves as a roadmap for identifying gaps in SFR and prioritizing future studies. The figure represents a strategic diagram, helping to identify past trends, current focal points, and potential future research directions. It is structured into four quadrants based on development degree (density) and relevance degree (centrality).

The topics in the top-right quadrant (Motor Themes – Highly Developed and Central) are both well-developed and highly relevant to the field. Includes *sustainable finance, sustainability, sustainable development* with high frequency. Future Trend: These topics will continue to drive research, with particular attention to sustainable investment, ESG, CSR, sustainable and green banking. Here we see also g*reen finance, green credit (policy), green investment* – these are positioned between motor and niche themes, indicating that they are actively growing research areas. Regarding the policy level worth to note that *green regulation* belongs also to this group.

The topics in the top-left quadrant (niche themes – highly developed but isolated) are well-developed but not central to the overall research field. Includes *climate finance, adaptation, green climate fund* – suggesting that these are specialized areas but may not be widely connected to the broader current research on sustainable finance. The role of climate adaptation financing may gain more prominence.

Worth to note that there is no topic in the bottom-right quadrant (basic themes – central but less developed). These would be fundamental themes that are widely discussed but still under development in terms of research depth.

The topics in the bottom-left quadrant (emerging or declining themes – less central and less developed) are either emerging research areas or declining in importance. Includes *weather derivatives, weather risk*, *risk management, and hedging* indicating that financial tools for weather-related risks are either underexplored or becoming less relevant in this particular research field. If these topics are still relevant in real-world finance, we might see a revival or integration into broader climate risk management studies.

In the mid-Space (Transitional or Overlapping Themes) we find two groups. *Climate change, carbon finance, renewable energy*, and also SDGs appears at the intersection of basic and motor themes, showing that while these are highly relevant, more detailed studies and frameworks are still evolving. Expect continued growth in research on carbon markets, energy transition, and policy frameworks for achieving sustainability goals. *Green bonds, COVID-19, environmental finance*, and *climate risk* are at the intersection of basic and emerging themes, suggesting that these are important but may need further integration into mainstream SFR. Regarding environmental finance our periodization suggests that it will rather move to the declining themes by time.

In addition to the above themes, 3 key issues are emerging in the related international discourse which will also have a major impact on research in the coming years:

- How can green technologies and innovation be financed and stimulated through the financial system?
- How can large databases be used in SF to increase efficiency and support the achievement of sustainability goals?
- How to raise awareness of the importance of SF among financial actors and society at large, and how to encourage sustainable financial choices?

Beyond the specific themes, it can be said that the most certain feature of future research is that it will deepen its interdisciplinary character. The renewal of the financial profession cannot do without deeper cooperation between economics and the natural sciences and the development of new methodologies for data analysis.

We can also be confident that, as time goes by and methodologies evolve, traditional financial journals will become more open to publishing studies on sustainable finance. This is also an important springboard for shaping public opinion and increasing related scientific capacity. (Sárvári, 2024)

**Limitations**

While this study presents an extensive bibliometric analysis of sustainable finance research, certain limitations must be acknowledged. First, the analysis relies on data from Scopus and Web of Science, which, despite being comprehensive, may exclude relevant works indexed in other databases or non-English publications. Second, the bibliometric method primarily captures quantitative aspects – such as publication counts, citations, and co-authorship networks – potentially overlooking nuanced qualitative insights, theoretical advancements, or emerging concepts not yet widely cited. Third, the periodization proposed is informed by observable trends in the data, which may evolve as new frameworks and paradigms emerge in response to future socio-economic and environmental shifts. Finally, the study's reliance on

keywords and author-provided terms introduces a risk of bias or misclassification, especially given the diverse and evolving terminology surrounding sustainable finance. Acknowledging these limitations underscores the need for complementary qualitative reviews and interdisciplinary perspectives to fully capture the dynamic landscape of sustainable finance research.

**Acknowledgement**

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**Appendix**

**Table A.1. The top 15 documents according to the numbers of local citations, and global citations**

| Documents | Year | Local Citations | Document | Year | Global Citations |
|---|---|---|---|---|---|
| Zerbib Od, 2019, J Bank Financ | 2019 | 289 | Bodis K, 2019, Renew Sust Energ Rev | 2019 | 702 |
| Flammer C, 2021, J Financ Econ | 2021 | 255 | Lee Cc, 2022, Energy Econ | 2022 | 446 |
| Tang Dy, 2020, J Corp Financ | 2020 | 234 | Yu Ch, 2021, Energy Policy | 2021 | 431 |
| Taghizadeh-Hesary F, 2019, Financ Res Lett | 2019 | 217 | Zhang D, 2021, Energy Policy | 2021 | 418 |
| Meo Ms, 2022, Borsa Istanb Rev | 2022 | 179 | Flammer C, 2021, J Financ Econ | 2021 | 412 |
| Reboredo Jc, 2020, Econ Model | 2020 | 176 | Zerbib Od, 2019, J Bank Financ | 2019 | 410 |
| Gianfrate G, 2019, J Clean Prod | 2019 | 175 | Shen Y, 2021, Sci Total Environ | 2021 | 391 |
| Hachenberg B, 2018, J Asset Manag | 2018 | 157 | Taghizadeh-Hesary F, 2019, Financ Res Lett | 2019 | 361 |
| Liu Jy, 2017, J Clean Prod | 2017 | 147 | Hu G, 2021, Energy Econ | 2021 | 330 |
| Zhang B, 2011, J Environ Manage | 2011 | 141 | Tang Dy, 2020, J Corp Financ | 2020 | 322 |
| Broadstock Dc, 2019, Financ Res Lett | 2019 | 135 | Reboredo Jc, 2018, Energy Econ | 2018 | 316 |
| Febi W, 2018, Financ Res Lett | 2018 | 120 | Aguirre M, 2014, Energy Policy | 2014 | 305 |
| Campiglio E, 2016, Ecol Econ | 2016 | 105 | Mazzucato M, 2018, Technol Forecast Soc Chang | 2018 | 303 |
| Zhang K, 2021, J Environ Manage | 2021 | 104 | Campiglio E, 2016, Ecol Econ | 2016 | 295 |
| Aizawa M, 2010, J Environ Dev | 2010 | 99 | He L, 2019, J Clean Prod | 2019 | 285 |

*„Szerkesztett formában megjelent 2026. február 5-én a Taylor and Francis Online portal oldalán.”*