Araştırma Makalesi / Research Article

A Bibliometric Analysis of Climate Finance Using VOSviewer

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Abstract

Climate change and finance are among the leading research areas that have been receiving increasing attention in the literature in recent years. The aim of this study is to examine articles published on this theme over the last twenty years. Thus, a literature review covering the years 2004-2024 was conducted using bibliometric analysis methods based on the Web of Science database and the VOSviewer programme. Using the keywords 'climate-finance' in the Web of Science (WoS) database, a total of 1,109 studies were identified. This study utilised citation analysis, bibliometric coupling, co-citation, co-authorship, and keyword analysis methods, which were explained through visualisation. The fundamental assumptions of this bibliometric analysis study on this issue, the years in which the subject was addressed in the literature, its distribution by country and scientific discipline, the methods, the prominent keywords, and the structure of scientific collaboration in this field are detailed in tables and figures.

Keywords: *Climate, Finance, Bibliometric Analysis, Vosviewer*

JEL Codes**:** *Q54, G00, C88, O13*

VOSviewer Kullanılarak İklim-Finans Üzerine Bibliyometrik Bir Analiz

Öz

İklim değişikliği ve finans, son yıllarda literatürde giderek artan bir ilgiyle ele alınan başat araştırma alanları arasında yer almaktadır. Bu çalışmanın amacı son yirmi yılda bu tema üzerine yayınlanan makaleleri incelemektir. Böylece Web of Science veritabanına dayalı ve VOSviewer programı kullanılarak bibliyometrik analiz yöntemleri ile 2004-2024 yıllarını kapsayan bir literatür taraması yapılmıştır. Web of Science (WoS) veritabanında "iklim-finans" anahtar kelimeleri kullanılarak, 2004-2024 yılları arasında toplam 1.109 çalışma tespit edilmiştir. Bu çalışmada atıf analizi, bibliyometrik eşleştirme (bibliographic coupling), ortak atıf (co-citation), ortak yazarlık (co-authorship) ve anahtar kelime analizi yöntemleri kullanılmış ve görselleştirilerek açıklanmıştır. İklim ve finans üzerine yapılan bu bibliyometrik analiz çalışmasının temel varsayımları, konunun literatürde ele alındığı yıllar, ülke ve bilimsel disiplinlere göre dağılımı, kullanılan yöntemler, öne çıkan anahtar kelimeler ve bu alandaki bilimsel işbirliği yapısı tablo ve görsellerle detaylandırılmıştır.

Anahtar Sözcükler: *İklim, Finans, Bibliyometrik Analiz, Vosviewer.*

JEL Kodları: *Q54, G00, C88, O13*

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1. Introduction

Climate change is currently one of the main topics on the international agenda. Definitions exist in the literature on climate change and related topics. According to the United Nations (2025), climate change is the phrase used to describe long term changes in global temperatures and weather patterns. These changes have mostly been caused by human activities since the 1800s, especially the burning of fossil fuels like oil, coal, and natural gas. However, they can also ocur naturally due to events like large-scale volcanic eruptions or changes in solar activicty. Climate scientists emphasize that nearly all of the global warming that has taken place over the past 200 years is due to human activity. The earth is warming at a rate that hasn't been seen in at least the last 2,000 years due to greenhouse gas emissions from industrialization, energy production, and different kind of human activities. The Earth's average surface temperature is today 1.2°C higher than it was before the Industrial Revolution and warmer than it has ever been in the preceding 100,000 years. Additionally, every decade since 1850 has been hotter than the one before it, with the warmest decade ever recorded taking place between 2011 and 2020 (UN, 2025).

Climate finance has emerged as a crucial instrument in the global response to climate change. It includes funds allocated to initiatives aimed at lowering greenhouse gas emissions and getting ready for the consequences of climate change. These funds are intended to support initiatives that lower environmental hazards and increase resilience to climate-related difficulties. They may come from public, private, or other sources. The significance of climate financing in promoting sustainable development is becoming more widely acknowledged as the world economy moves toward a low-carbon model (United Nations Framework Convention on Climate Change,2025).

In academic and policy circles, the nexus between climate change and finance, or "climate finance," has attracted a lot of interest. The money needed to support mitigation and adaptation activities, such as investments in renewable energy, sustainable infrastructure, and resilience-building projects, is referred to as climate financing. Scholarly interest was further sparked by the 2015 passage of the Paris Agreement, which aims to reduce global warming and raise funds for climate action (Kouwenberg & Zheng, 2023). The area of climate finance is still complex and nuanced, with many fields giving different viewpoints, despite the expanding corpus of literature. Bibliometric analysis provides a methodical way to trace the development, organization, and thematic focus of research in this field in order to navigate this complexity. Co-authorship networks, keyword co-occurrences, and citation patterns can be seen using tools like VOSviewer, which offer insights into the theoretical foundations and new developments in climate finance research (Afifah et al., 2024).

In this regard, there is a need to conduct research examining the relationship between finance and climate concepts, which are attracting intense interest on a global

scale. In this study, we wanted to investigate the relationship between this issue, which is particularly preoccupying the United Nations agenda, and finance. The main subject of the research is 'How have academic publications in the fields of climate change and finance developed and changed between 2004 and 2024?'.The study also examines how climate finance research has been distributed over time and when significant increases have occurred. Which authors, organisations and countries have made the greatest contributions to this field? Which scientific disciplines and methods stand out in the literature? How is scientific collaboration between countries and authors organised? What are the most frequently used keywords and how have they changed over time? This research aims to make an original contribution to the literature by systematically reporting the answers to the questions in question. Furthermore, the distinctive feature of this study is that the findings obtained are intended to serve as a guide for future work in this field.

The study consists of six main sections. The first section of the article serves as an introduction, and the remaining sections are structured as follows: the second section presents a literature review; the third section describes the dataset and methodology; the fourth section covers the analysis and discussion; the fifth section presents the network visualisations; and the final section concludes the study.

2. Literature Review

Studies containing the keywords 'climate-finance' were analyzed using the Web of Science database, which spans the years 2004–2024. As a result of the research, a total of 1,109 studies were identified. These studies have been ranked by the number of citations and presented in tabular form. This table provides basic information about the sources reviewed in the literature analysis conducted using the Web of Science database. The studies listed in the table are ranked in descending order according to the quantity of citations. The names of the authors, the year of publication and the name of the journal in which it was published are provided in detail in the appendix added at the end of the study. In addition, studies that are directly related to financial issues have been categorized separately. Stern (2008), Tol (2009), Nordhaus (2019), Dafermos, Nikolaid, & Galanis, (2018), Hong, Karolyi, & Scheinkman, (2020), Banga (2018), Akomea-Frimpong, Adeabah, Ofosu, & Tenakwah (2021),Giglio, Kelly, & Stroebel (2021) , Khan, M. A., Riaz, H., Saeed, A., & Zubair, S. (2022), Stroebel & Wurgler (2021), work directly related to finance issues.

3. Data and Methodology

Bibliometric analysis is a research approach that utilizes academic publication outputs to identify global research trends within a specific field (Alsharıf, 2020, p. 2949). The studies included in such analyses aim to statistically examine various elements, including the authors, their affiliated countries and institutions, keywords, and citation data. The obtained data were converted into tables, networks and visuals using the

Vosviewer software program. Studies addressing climate and finance issues within the period from 2004 to 2024 were examined through the WoS database, and bibliometric analysis was conducted based on the data obtained.

4. Results, Analysis and Discussion

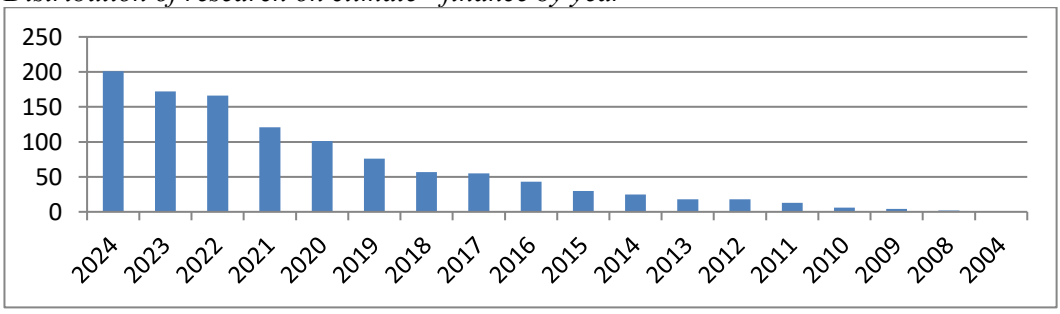
The increase observed in the findings over the last five years, according to the distribution of research on climate and finance by year, is noteworthy. The number of studies was 76 in 2019, 101 in 2020, 121 in 2021, 166 in 2022, 172 in 2023, and 201 in 2024. When examining the distribution of research on climate and finance by country, the United States, England, Germany, China and Australia are the top five countries. The disciplinary distribution of climate and finance-related publications was retrieved from the WoS database. The findings show that the majority of studies are concentrated in the areas of Environmental Studies, Environmental Sciences, Economics, and Green and Sustainable Science & Technology, respectively. In addition to these findings, Citation Analysis (including citation document images, citation author images, and citation author country images), Bibliometric Matching Analysis (document, author and country images), Co-Citation Analysis (with images of cited references and cited authors), Co-Author Analysis (with images of co-authors and country collaboration) and Keyword Analysis findings are also detailed with images within the text.

4.1. Distribution of research on climate and finance by years

As can be seen from the table, the years 2022-2024 were the years with the most publications. As of the 2020s, it can be said that climate and finance issues have become more prominent.

Figure 1

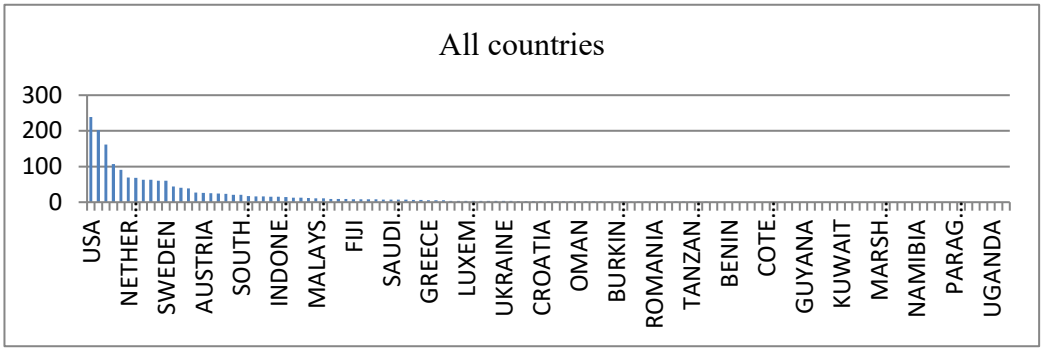
Distribution of research on climate - finance by year



4.2. Distribution of research on climate and finance by country

When the distribution of climate and finance research by country is analyzed, it is observed that the United States, England and Germany rank among the top three. China and Australia follow them. Among developing countries, China 107 and India 63 rank among the highest, while South Africa has 40, Brazil 17, Russia 8, Turkey 7, and Mexico 6 studies.

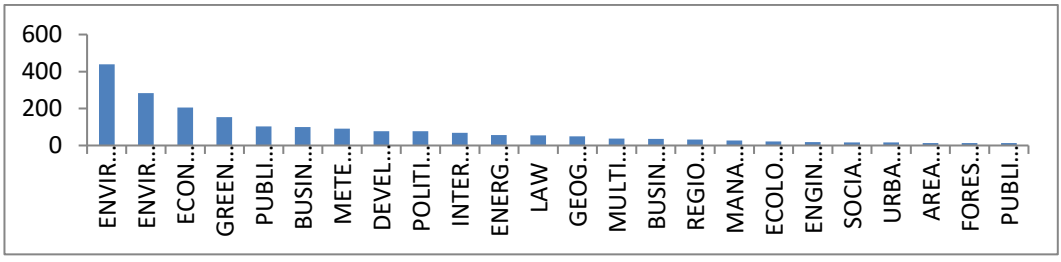
Figure 2
Distribution of climate and finance related research by country



4.3. Classification of climate and finance-related research by field of study

The distribution of studies on the subject according to disciplines was acquired from the WoS database. Accordingly, it is evident that majority of research is conducted in the domains of Environmental studies, Environmental sciences, Economics, Green sustainable science technology, respectively.

Figure 3
Distribution of research on climate and finance by disciplines



5. Network Visualisation

In this bibliometric study conducted using Vosviewer; firstly citation analysis, secondly bibliometric matching analysis, thirdly co-citation analysis, fourthly co-authorship analysis and finally keyword analysis were performed. The outputs obtained as a result of the analyses and the evaluations made are explained in this section.

5.1. Citation Analysis

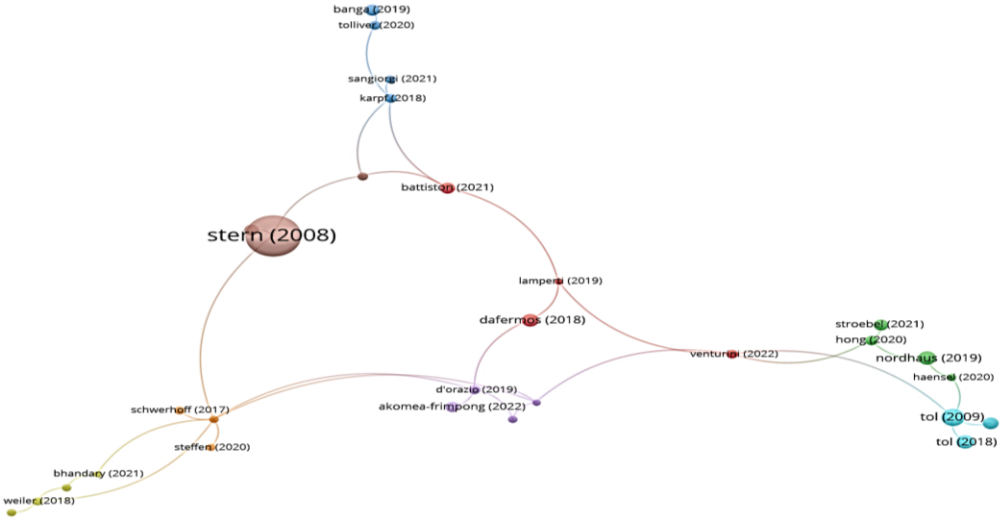
Citation analysis in VOSviewer recognizes the number of times documents (such as articles) have been cited by other publications. This method helps to determine which documents are the most significant within a certain academic subject. The following lists the studies of citation documents, citation authors, and citation countries that were carried out as part of citation analysis process utilizing the VOSviewer mapping approach.

5.1.1. Citation Analysis: Citation document image

The author documents shown in Figure 4 were calculated with a minimum citation count of '1', and 50 author documents were reached. The top 7 most cited author documents are Stern (2008) with 4006 citations, Tol (2009) with 673 citations, Nordhaus (2019) with 423 citations, Tol (2018) with 415 citations, Dafermos (2018) with 364 citations, Hsiang (2016) with 346 citations, Giglio et al. (2021) with 308 citations. The red cluster consists of studies directly related to Stern (2008) and expanding the conceptual framework of this study (e.g.,Battiston (2021), Lamperti (2019), Dafermos (2018)). Therefore, the fact that Stern's (2008) study is represented by a relatively larger node on the map may indicate that this study serves as a central and fundamental reference in the literature.

Figure 4

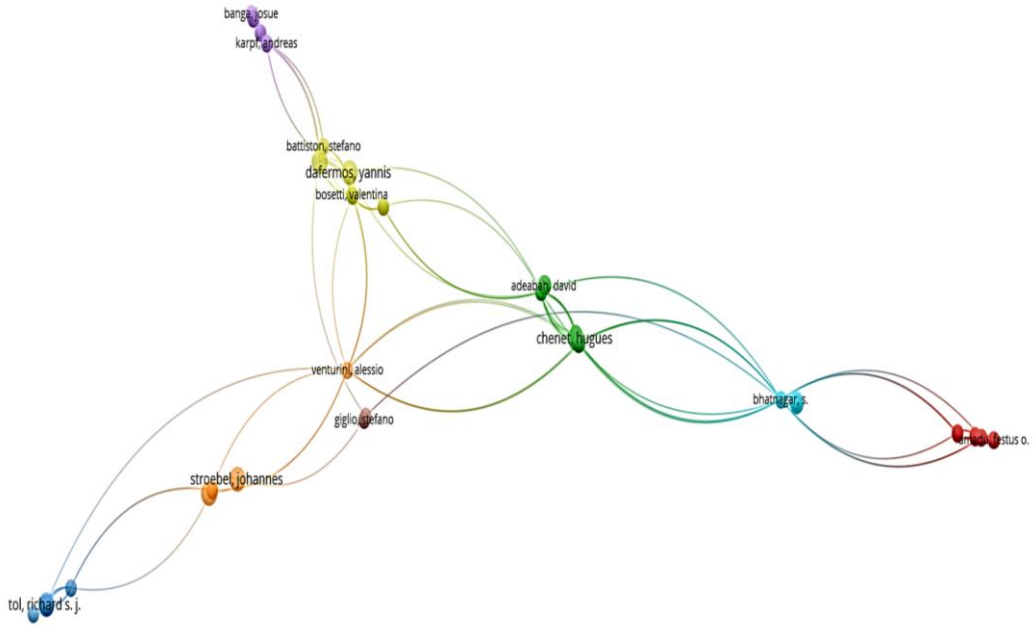
Citation document image



5.1.2. Citation Analysis: Citation of author image

This visual shows how many times authors have been cited in academic studies, which authors play a central role in this field, the intensity of intereaction between authors, and changes in citation counts over time. The strength of connections among highly cited authors is shown in figüre 5 below. In the visualisation, the minimum number of documents per author and the minimum number of citations per author's document is set to '1'. Of the 144 authors, 144 correspond to these values. In the green cluster Chenet, RyanCollins, and Van Lerven (2021), in the yellow cluster Dafermos, Y., Nikolaidi, M., & Galanis, G. (2018), in the orange cluster Stroebel, J., & Wurgler, J. (2021), and in the blue cluster Tol, R. S. J. (2009) represent the largest nodes and consist of authors with dense citation relationships with all other clusters, representing the core literature of the field.

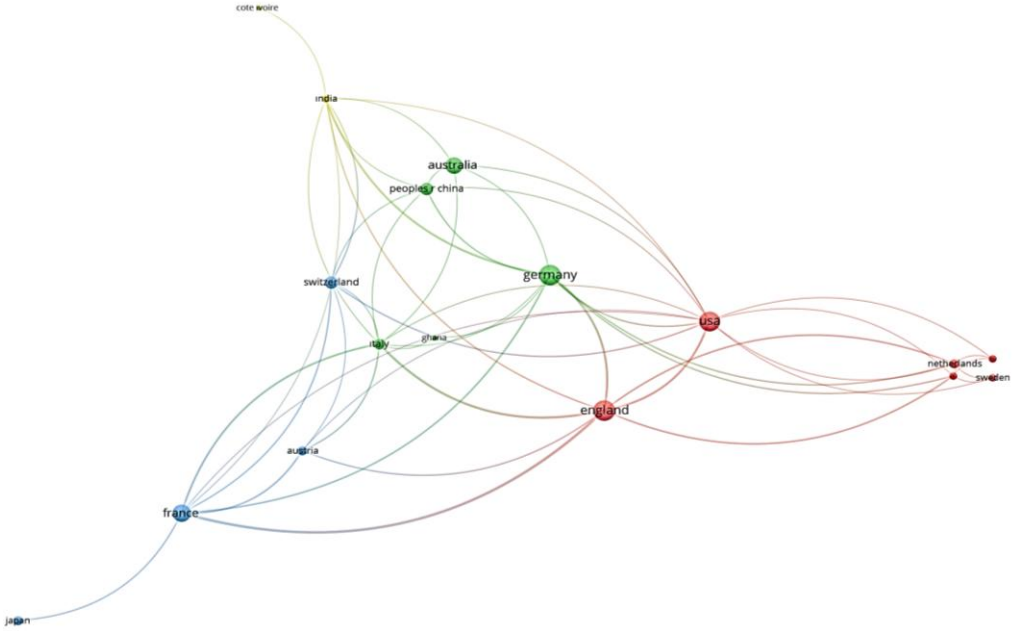
Figure 5
Citation of author image



5.1.3. Citation Analysis: Citation country image

Figure 6 shows a network diagram of countries that have conducted research on climate and finance. The minimum number of documents per country and the minimum number of citations per country have been set to '1'. All 37 countries correspond to this value. The connection lines highlight the international nature of research on climate and finance by showing the citation links and research collaboration between countries such as the England, France, Germany, the United States, and Italy. The red cluster in the visual represents one of the strongest and most visible structures. The United States, in particular, occupies a central position in the literature in terms of node size and number of connections. The United Kingdom acts as a bridge in the flow of citations between Europe and the United States. The visual reveals that the literature has a multi-centered but USA-focused structure. The United States and Germany stand out as the two main centers of attraction in the citation network.

Figure 6
Citation country image



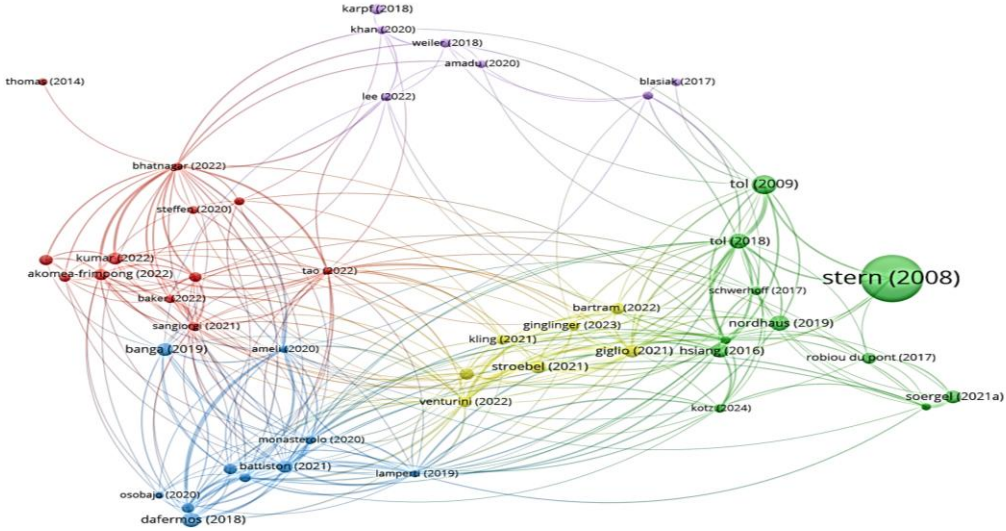
5.2. Bibliometric Coupling Analysis

Bibliographic coupling analysis, which refers to two different sources citing the same reference, demonstrates the strength of the connection between studies. Within the scope of this analysis, conducted using the VOSviewer mapping method, bibliographic document, author, and country network visualizations were generated and analyzed.

5.2.1. Bibliometric Coupling Analysis: Document image

The bibliometric matching map created with VOSviewer shows the connection strength of authors according to the document in Figure 7. This visualisation was created with a minimum citation count of '1' for each document. All 50 documents correspond to this value. The author documents with the most bibliometric matches on "climate finance" subjects are listed in order of the top six documents with the highest total link strength: Venturini (2022), Tol (2018), Giglio (2021), Battiston (2021), Lamperti (2019). One of the most prominent clusters in the visual is the green cluster. In particular, the large node size and the importance of Stern's (2008) work indicate that this cluster contains fundamental and reference studies in the field. Furthermore, the red cluster represents current and intensely interacting publications in the literature, while the blue cluster represents publications that are fewer in number but have strong connections with each other.

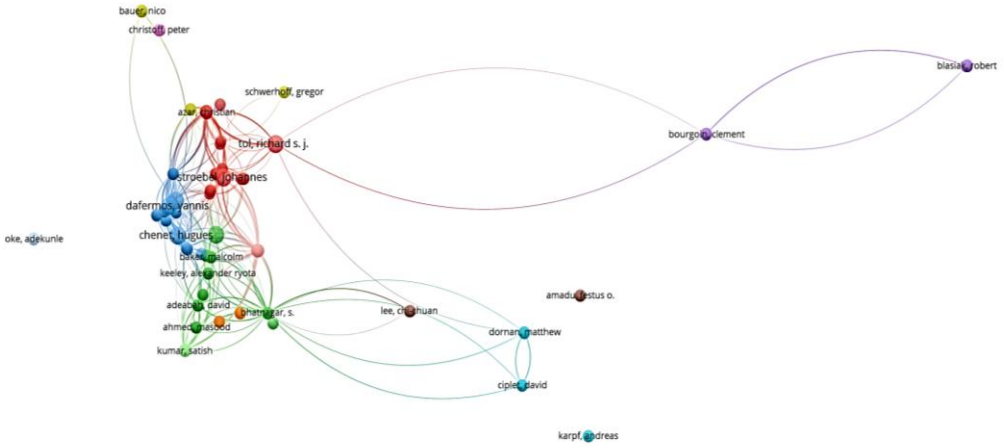
Figure 7
Document image



5.2.2. Bibliometric Coupling Analysis: Author image

Figure 8 shows the authors with the highest connection strength. When generating the visual, the minimum number of documents and citations for an author was set to '1'. Of the 144 authors, 144 correspond to this value. The figure shows a strong connection between the red, green, and blue color clusters. This indicates that the field has become interdisciplinary in nature. The multiple connections between the clusters reveal that this group is a reference center in the literature. The most interactive authors in these color clusters are Tol, Stroebel, Dafermos, Battiston, and Chenet.

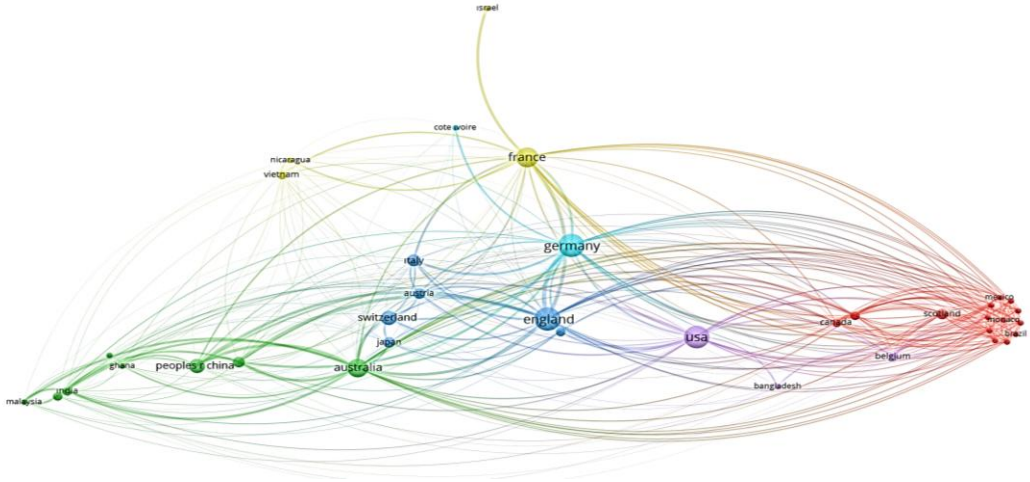
Figure 8
Author image



5.2.3. Bibliometric Coupling Analysis: Country visual

The visual representation of countries' network strength is shown in Figure 9. It was created by selecting a minimum value of '1' for both the number of documents and the number of citations for each country. 37 of the 37 countries correspond to this value. The top five countries are, in order, England, Australia, Germany, France and USA. The countries forming the largest clusters are France in the yellow cluster, Germany and the UK in the blue clusters, and the USA in the purple cluster, and they have strong reference ties with each other. The purple cluster is USA-centered and has a more limited but specific common reference structure with countries such as Bangladesh. The red cluster includes countries such as Scotland, Brazil, and Canada and exhibits a high degree of common references within itself.

Figure 9
Country visual



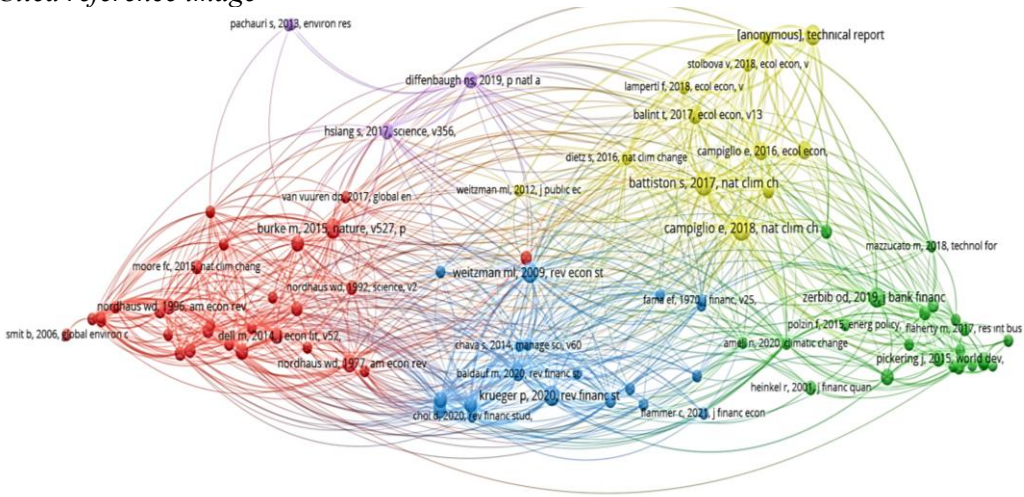
5.3. Co-Citation Analysis Visuals

The analyses of the cited references and authors' images within the scope of the co-citation analysis conducted using the Voswiever mapping method are detailed below.

5.3.1. Co-citation analysis visuals: Cited reference image

The visual representation of the cited references is available in Figure 10. This network map was created by selecting a minimum threshold value of '3' for the number of citations of a cited reference. Of the 3,775 cited works, 91 correspond to this value. Campiglio vd.(2018), Battiston vd. (2017), Weitzman (2009), Krueger vd. (2020) are the authors of the most frequently co-cited works. The largest nodes in the yellow and blue clusters also belong to these authors. The red cluster contains early works by authors such as Nordhaus and Stern that have received numerous citations. The central position of this cluster may indicate that these works form the theoretical foundation of the field.

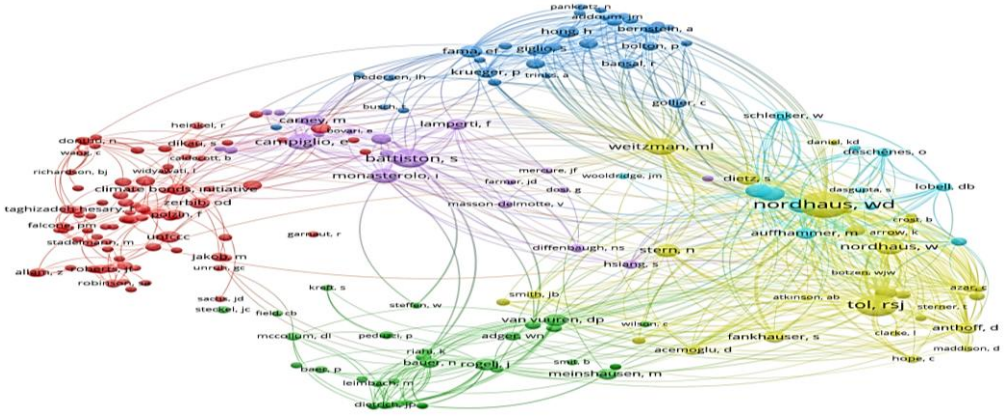
Figure 10
Cited reference image



5.3.2. Co-Citation Analysis: Image of cited authors

The network visualisation of the cited authors is shown in Figure 11.This network map was created by selecting a minimum citation count of '3' for each author. Of the 2690 authors, 242 correspond to this value. According to the visual, Nordhaus, Tol, Weitzman, and Battiston stand out as the largest nodes, and it can be concluded that they are the authors with the highest total strength power. This indicates that their works are positioned as fundamental references that are frequently cited together in the literature. Furthermore, three of these authors are in the yellow group, and the yellow cluster has strong co-citation ties with all other clusters. This may indicate that these authors are fundamental references in this field.

Figure 11
Image of cited authors



5.4. Co-Authorship Analysis Visuals

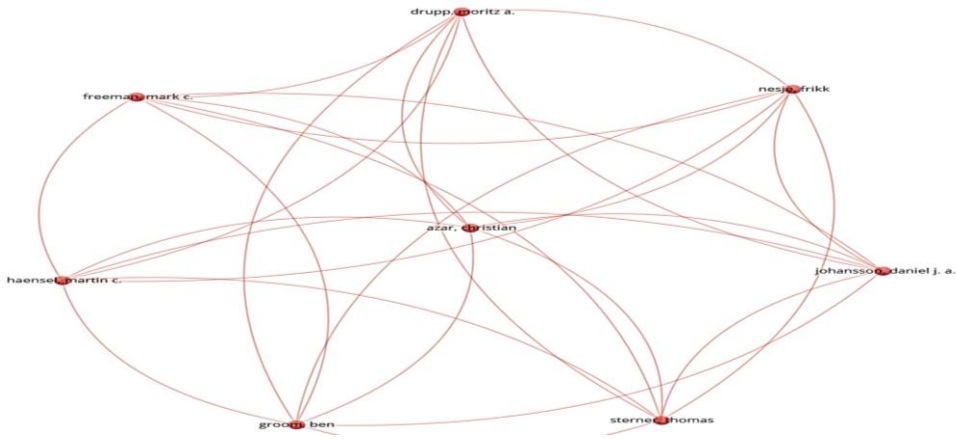
The co-authorship analysis conducted using the Voswiever mapping method is explained below, followed by the co-author and co-country visual analyses.

5.4.1. Co-Authorship Analysis Visuals: Co-author image

The co-authorship analysis displays the network relationships between authors who have worked together on a collaborative study. Figure 12 displays the co-authorship visualization of studies retrieved from the WoS database. The co-authorship analysis visualisation was created by selecting a minimum of '1' for the number of documents per author and the number of citations per author's document. Of the 144 authors, 144 correspond to this value. The visual shows that all authors are located within a single red cluster and that there are dense, bidirectional connections between them. The visualization is a single-color map that illustrates the dense, bidirectional relationships between all writers and their location within a single red cluster.

Figure 12

Co-author image



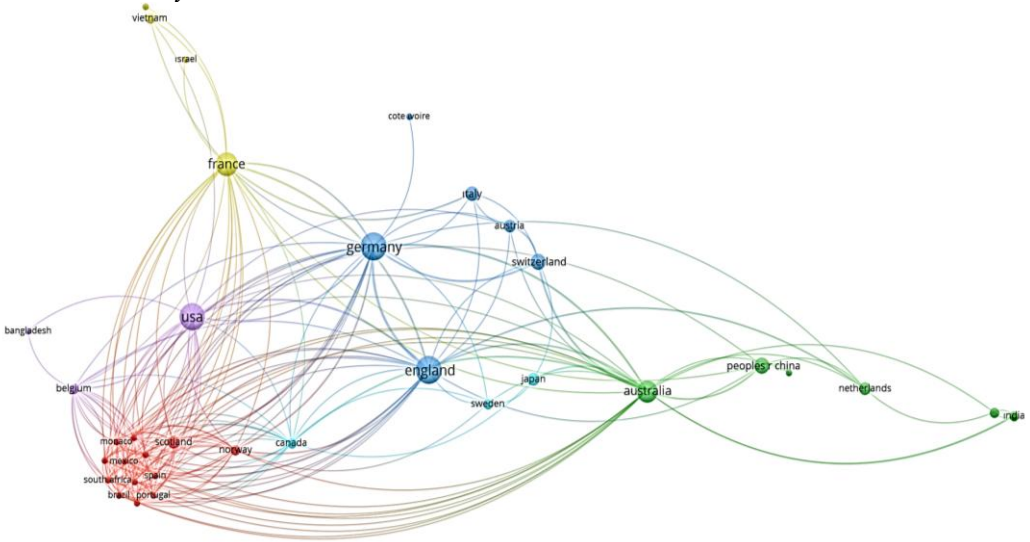
5.4.2. Co-Authorship Analysis: Common country visual

This analysis examines co-publications between institutions, countries, or authors. Country-based co-authorship analysis is conducted to identify the most active countries in a specific research field, evaluate the level of cooperation between them, and reveal network structures. A common country visualization of the studies accessed from the Web of Science database is shown in Figure 13. The common country visualization was created by selecting a minimum of '1' for both the number of documents and the number of citations for each country. 37 out of 37 countries correspond to this value. Of the 37 countries, 37 meet the thresholds. The map shows that Germany, Australia, the United Kingdom, France, and the United States stand out in terms of co-authorship activities and are located close to each other. In other words, the top five countries in the field of co-

authored research are, in order, Germany, Australia, the United Kingdom, France, and the United States. Additionally, these countries are the ones with the largest clusters in different colors. Red cluster includes countries such as Scotland, Norway, Portugal, Spain and Brazil. High node density and multi-directional connections indicate that these countries engage in high co-authorship and multidisciplinary collaboration in the literature. The green cluster includes China, Australia, India, and the Netherlands, with particularly strong links observed between China and Australia. This structure may be said to reflect regional concentration where developing economies, sustainable growth, and environmental finance themes are prominent. Germany, the United Kingdom, Italy, Austria, and Switzerland are in the blue group and are at the center of the high connection level.

Figure 13

Common country visual



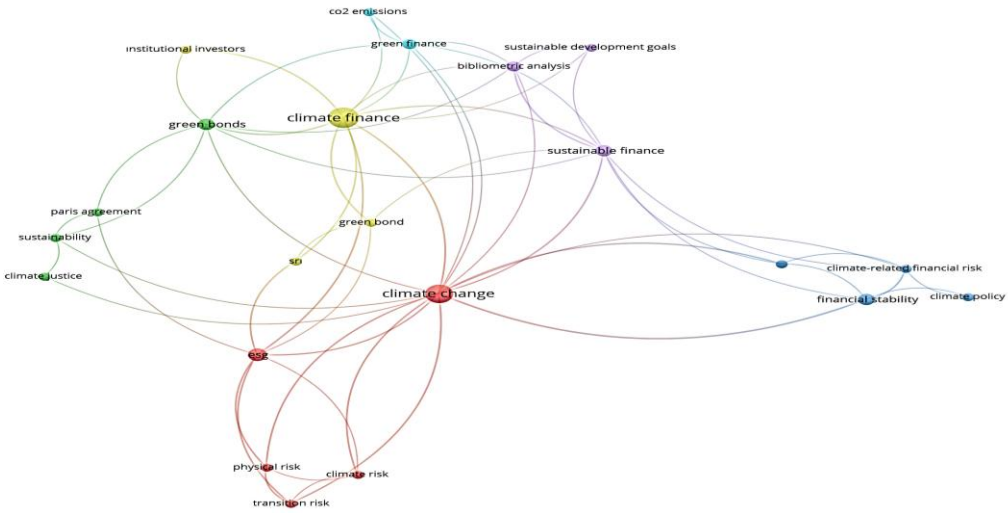
5.5. Keyword Analysis Visuals

Keyword analysis is a significant bibliometric analysis technique used to determine research trends, popular topics, and the connections between concepts within a specific field of academic literature. This type of analysis makes it possible to see the most popular keywords related to a particular topic, as well as the relationships among them.

The keyword analysis of the studies accessed from the WoS database is shown in Figure 14. A minimum of 2 occurrences of a keyword was set as the criterion for this analysis, and 22 of the 146 keywords met this value. According to the keyword analysis, the most frequently used terms were climate finance, climate change, ESG, sustainable finance and green bonds. The two largest nodes, ‘’climate finance’’and ‘’climate change’’, are shown in yellow and red clusters. The yellow cluster contains keywords

such as ‘climate finance’, ‘green bonds’ and ‘green bond’, indicating that it is treated as an integrative concept in the literature. The blue cluster includes concepts such as ‘climate policy,’ ‘financial stability,’ and ‘climate-related financial risk,’ the green cluster encompasses concepts such as ‘sustainability,’ ‘Paris Agreement,’ ‘green bonds,’ and ‘climate justice,’.This demonstrates that climate finance literature has evolved from a climate risk-centered structure to a multidimensional thematic integration centered on climate finance, sustainability, and financial stability.

Figure 14
Keyword Analysis



6. Conclusion

Taking action to improve current living conditions and protect future generations' right to live in a healthy environment is no longer optional, it is a necessity. In addition to how climate change affects society, it will also have significant economic effects. It is expected that the economies of underdeveloped and developing nations will be more affected by climate change than developed nations. So, climate and finance have become widely studied topics in international academic literature in recent years. Thus, using the keywords “climate-finance” in the WoS database, a total of 1.109 studies were identified between 2004 and 2024. These studies were classified by year, country, and field and added to the study in graphical form.

Once more, for these studies, citation analysis, bibliometric matching analysis, co-citation analysis, co-author analysis, and keyword analysis were performed, and network visualizations were added to the study. During these analyses, interpretations were also made regarding the colours in the visuals and the sizes of the nodes. In each analysis, the colours represent different meanings, while the sizes of the nodes are related to the

numerical magnitude of the relevant topic.

In this context, the study provides an overview of climate and finance issues, and the following conclusions have been drawn. In terms of the number of studies by year, with 201 studies, 2024 was the year with the most publications. Based on the distribution of the study over the years, it can be concluded that there has been an increase in the number of studies establishing a link between climate and finance.

The findings obtained from the above country distribution indicate that research on this subject is predominantly concentrated in developed countries. It also reveals that developing countries are contributing increasingly to the literature, but that this contribution is still limited. In terms of distribution by country, the United States ranks first with 240 studies. It is clear that research is largely concentrated in the United States, which is consistent with the results of bibliometric analysis. The United States' advanced research infrastructure, comprehensive financial markets, and the availability of data and methodological skills useful for analyzing climate finance linkages may help explain this situation. Furthermore, the country's leading position in the literature is supported by its interdisciplinary academic tradition and ongoing regulatory debates on climate policies.

In terms of the classification of climate and finance-related research according to their fields of study, environmental studies stand out with 439 studies. Looking at the table classifying research by field of study, it is evident that the existing literature is predominantly concentrated in the fields of environmental studies and environmental sciences. Research focused on finance, on the other hand, appears to be relatively limited. It is recommended that studies addressing the interaction between climate and finance be increased.

In conclusion, this study evaluates joint scientific research on climate and finance, two current and important areas of research. It aims to contribute to the literature by identifying gaps in the literature on these topics. From this perspective, the increasing number of studies in recent years can be viewed positively. Among the areas open to development are increasing the number and diversity of countries where studies are conducted and diversifying topics in the field of finance. Furthermore, the fact that the document search was conducted solely in the Web of Science database is the sole limitation of the study. Similar studies may be conducted in the future based on other databases.

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Ethical Statement: The author declares that scientific and ethical principles were followed in this study, and all sources used have been properly cited.

Artificial Intelligence Statement: The author declares that no generative artificial intelligence used in this study.

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Appendix A

Studies On ‘’Climate Finance‘’ In The Web Of Science Database

Author name	Year	Journal informaton	Citation
Stern, N.	2008	*American Economic Review*	4006
Tol, R. S. J.	2009	*Journal of Economic Perspectives*	673
Nordhaus, W. D.	2019	*American Economic Review*	423
Tol, R. S. J.	2018	*Review of Environmental Economics and Policy*	415
Dafermos et al.	2018	*Ecological Economics,*	364
Hsiang, S.	2016	*Annual Review of Resource Economics*	346
Giglio et al.	2021	Annual Review Of Financial Economics	308
Soergel et al.	2021	Nature Climate Change	301
Banga, J	2018	*Journal of Sustainable Finance & Investment*	295
Stroebel, J., & Wurgler, J.	2021	*Journal of Financial Economics*	287
Kumar et al.	2022	Annals Of Operatıons Research	275
Battiston et al.	2021	*Journal of Financial Stability*	273
Akomea-Frimpong et al.	2021	*Journal Of Sustaınable Fınance & Investment*	242
Robiou du Pont et al.	2017	*Nature Climate Change*	235
Bartram et al.	2022	*Journal of Financial Economics*	229
Hong et al.	2020	The Review of Financial Studies	218
Khan et al.	2022	*Borsa Istanbul Review*	214
Capasso et al.	2020	*Journal of Cleaner Production*	214
Venturini, A.	2022	*International Review of Financial Analysis*	197
Kling et al.	2021	*World Development*	193
Karpf, A., & Mandel, A.	2018	*Nature Climate Change*	193
Tolliver et al.,	2020	*Journal of Cleaner Production*	185
Ginglinger, E., & Moreau, Q.	2023	*Management Science*	173
Schwerhoff, G., & Sy, M**.**	2017	*Renewable & Sustainable Energy Reviews*	158