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# A Compilation of Relationships between Climate Change and Finance

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## Abstract

*Climate change is not a short-term process. It is a consequence of prolonged environmental damage by human beings. Results of climate change have been seen as the rise in the global average temperature, consequently raising the sea level, melting the glaciers, raising the degree of heat waves, droughts, and changes in the timing of monsoons, further impacting agriculture and ultimately impacting human lives and the whole ecological system. However, nowadays, researchers and investors are more concerned about the impact of climate change on the financial markets because it has been seen that climate change may impact them. In this paper, we adopted a bibliometric analysis approach. We used the analysis provided by Scopus based on the input keywords. Initially, we used three words: 'Environment,' 'Climate,' and 'Stock Market.' After further filtration of keywords, we limited the analysis to journal articles from 2013 to 2023 and obtained 510 documents. We found an upward trend in the number of publications. Further, authors from developed countries dominate this field. Our aim in compiling the essential papers that link the finance field to climate change is to provide a comprehensive view of the domain. This comprehensive view will help researchers, regulators, and investors to understand this emerging and crucial phenomenon.*

**Keywords:** Climate Change, Bibliometric, Stock Market

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## **1. Introduction**

Climate change is a long-term process or phenomenon of transformation in weather patterns and climate on the Earth. After a long research, researchers and scientists are in a position to say that climate change may be due to man-made events and activities. For example, greenhouse gases released by humans into the atmosphere are a significant factor in climate change. Besides this over-consumption of energy sources, many hydro-power projects, mining of minerals and fossil fuels, and deforestation may significantly contribute to climate change.

In the last few decades, severe results of climate change have been seen. For example, the rise in the global average temperature, consequently raising the sea level, melting the glaciers, raising the degree of heat waves, droughts, and changes in the timing of monsoons, further impacting agriculture and ultimately impacting human lives and the whole ecological system. However, nowadays, researchers have seen the impact of climate change beyond the physical damage. Some studies found that it may also affect the financial markets through changes in policies and regulations related to climate change (Noh & Park, 2023). However, in a broader sense, it impacts the global economy and human society through damage to the global ecological system (Bebbington & Larrinaga-González, 2008).

The United Nations Climate Change defines two types of action at the national and international levels to tackle climate change. First is climate change mitigation, and second is climate change adaptation. Climate change mitigation means reducing greenhouse gas emissions and controlling global warming. Greenhouse gas emissions can be reduced by reducing the sources of greenhouse gases, such as burning fossil fuel, or by enhancing the



sources that sink or absorb the greenhouse gases, such as forests and oceans. Climate change adaptation involves reducing the damage from existing climate change; for example, rain harvesting is a better option to reduce droughts and groundwater crises.

The year 2015 was significant in terms of policy shaping regarding transforming the world into a sustainable environment through 17 sustainable development goals. Since then, environmental concerns have been rising nationally and internationally. Countries' actions regarding achieving the United Nations Sustainable Development Goals (SDGs) have become more significant for the financial sector in responding to these concerns. On a worldwide scale, central banks and leading actors in the banking industry pledged to assist in promoting environmentally sustainable financial products at the Paris "One Planet Summit" in December 2017. Climate change is becoming a primary concern for customers, investors, and regulators (Ardia et al., 2022).

Contrary to this, some researchers believe that rapid and unlimited economic growth in a finite system leads to climate change. For example, China has enjoyed rapid economic growth over the last few decades and is also considered the world's largest carbon emitter. Additionally, carbon emission decreases air quality and increases global warming, badly affecting public health and, ultimately, the country's economy (Wu et al., 2021; Umar et al., 2021).

Unlike the previous bibliometric studies, this study mainly focused on climate change and the relationship between the stock market. As discussed earlier, climate change significantly impacts the stock market's performance. Our study compiles the studies that reveal the relationships between climate change and stock market performance. Our aim in compiling the essential papers that link the finance field to climate change is to provide a comprehensive view of the domain. This comprehensive view will help researchers, regulators, and investors to understand this emerging and crucial phenomenon. Researchers and academicians, in particular, may explore more aspects to study further in this field with the help of this paper.

In this paper, we adopted a bibliometric analysis approach. We used the analysis provided by Scopus based on the input keywords. Initially, we used three words: 'Environment,' 'Climate,' and 'Stock Market.' After further filtration of keywords, we limited the analysis to journal articles extracted only from the Scopus database from 2013 to 2023 and obtained 510 documents.

With the help of bibliometric analysis, we found that the number of publications showed upward trends in the selected time zone. Studies related to climate finance are actively conducted in China and followed by the United States and the United Kingdom. Notably, the Switzerland-based MDPI's *Sustainability* stands out, leading the way with 28 publications during the selected time period. Following closely is the Springer-based *Environmental Science and Pollution Research* journal, which ranks as the second most active journal in climate finance research. Economics and related fields, such as econometrics and finance, lead the list, boasting the highest number of published documents. Interestingly, while climate change is inherently linked to environmental issues, environmental science ranks second in terms of document count. As we have discussed, the economic field leads in this domain, and obviously keywords related to this field lead the list, such as 'Stock Market' and 'Financial Market'.

This paper is divided into the following sections. Section 2 explains the related literature, Section 3 explains the research methodology and procedures adopted in this paper, Section 4 demonstrates the analyses and discussions, and Section 5 provides the conclusion.

## **2. Literature Review**

A literature review provides a summary of research work done in the domain. It helps to interpret the prior work done and provides an understating of different aspects of the field. We can know about key sources, regions, and arguments within the field with the help of a

literature review. We arrange our literature review according to different themes. This can help the readers to explore the different aspects of the field. The themes are discussed hereafter.

### *2.1. Climate change and finance: an introduction*

In the recent era, where the world faces significant climate change-related risks and financial crises, academicians and policymakers are more concerned about analyzing the relationships between climate change and different financial markets. For example, Noh & Park (2023) explain that climate change impact is not limited to physical risks such as floods, droughts, rising sea levels, or storms; it also influences policy formations related to climate change, such as carbon pricing policy. This, in turn, affects the financial market. At the same time, Labbat and White (2007) believe that carbon risk, a subset of climate change risk, comprises three types of risk: Regulatory risk, Physical risk, and Business risk. Dikau and Volz (2018) argue that achieving global climate targets requires financing sustainable and green investments and restricting funding for environmentally harmful activities.

### *2.2. Climate Change and investors' Preferences & sentiments*

Investor preference is considered an essential tool for examining the stock market performance. Many factors influence investor sentiment and help to change their perception of any specific industry or company. Climate change may be one of them. We found some studies that investigated the impact of climate change on investor perceptions. For example, Pástor et al. (2021) explain investor preferences regarding climate change risks by presenting an ESG asset pricing framework. They document that increasing concerns about climate change, investor preferences, and customer behaviour immediately affect stock market performance. Ardia et al. (2022) further test Pastor et al.'s (2021) proposed framework and find that investors pay more attention to green firms during unexpected increases in climate change concerns.

Interestingly, retail investors play a more critical role in climate change concerns than institutional investors. Choi et al. (2020) demonstrate that retail investors drive the prices of low-emission and carbon-intensive stocks during uninformative but salient weather events. Additionally, investor opinions and perceptions may be influenced by news on climate change and studies on business impact related to climate change. Santi (2023) finds that increased social interaction, debates, and studies on climate change can shift investor opinions from negative to positive.

### *2.3. Climate change and Firm's performance*

Not only do stock markets and investors perceive the impact of climate change, but it also affects firm performance. Many factors related to climate change, such as ESG rating, climate-related policies, and physical damage from climate change, have directly impacted the firm's performance. Literature supports the above statement as Matsumura et al. (2014) find that firms failing to meet environmental disclosure measures are comparatively more penalized. They also mention that firms may gain higher value if they limit their greenhouse gas (GHG) emissions. He et al. (2023) analyze the Chinese stock market and infer that comprehensive ESG ratings impact firm performance by reducing crash risk and increasing transparency. Abnormal weather changes can also impact firm performance. For instance, Choi et al. (2020) demonstrate that abnormally warm weather leads to stock price declines for firms with high carbon emissions. Similarly, Bertolotti et al. (2019) document the impact of extreme weather events on stock prices of U.S.-based electric utilities, observing significant price fluctuations after hurricane landfalls.

However, some studies, such as Bolton & Kacperczyk (2021) and Hsu et al. (2023), claim that stocks of firms with high carbon emissions yield higher returns than low carbon-emission firms.

#### *2.4. Climate-related policies and financial market performance*

Climate change can create transition risks, which refer to changes in environment-related policies. Policies related to Climate change impact the firm's operations and, ultimately, their value in the stock market. For example, carbon pricing policy may badly impact firms with high carbon emissions. Studies simultaneously examine the impact of climate policies on the stock market. Xu et al. (2023) document that share prices of fossil energy companies may drop due to low-carbon transition policies, while share prices of electric automobile companies may rise due to subsidies for new energy vehicles.

Additionally, environment-related regulations and policies influence stock prices and non-financial firms and impact banks and other financial institutions. Researchers are interested in studying the impact of climate change on a firm's debt financing capacity. For example, Kozak (2021) investigates whether debt financing costs increase when external pressure restricts financing for projects and enterprises with high greenhouse gas emissions. They find that high CO<sub>2</sub> emissions may increase the cost of debt financing for industries known for strong CO<sub>2</sub> emissions, such as energy, construction, production, and transport.

On the other hand, Zhou et al. (2018) and Jung et al. (2018) argue that high carbon risk exposure increases default risk, as it introduces uncertainty into current and future cash flows.

#### *2.5. Climate change news and financial market performance*

Another aspect that may affect the financial market performance is news related to climate change. Climate change news is an essential source of information related to climate change. These types of news can change the stock indices, particularly the green ones. So, studying the relationship between climate change news and financial market performance is significant. Many studies document these relationships, such as Fedorova & Iasakova (2024), Revealing that sentiments about climate change news may influence the stock market dynamics. They also state that investors move their investments to a more sustainable IT sector to tackle uncertainty related to climate change. Robinson et al. (2018) investigated climate news's impact on 'green' companies' stock returns. They find that stocks are more sensitive to climate news of the 'green' companies in the financial sector than those in other sectors. On the other side, an article by the IMF explains that the financial sector is more sensitive to climate news. In this article, the authors believe there is a surge in ESG (Environmental, Social, Governance) investing in emerging economies. This may be because of high climate threats in those economies.<sup>1</sup> Nyakurukwa and Seetharam (2023) find that investors are not very active in punishing or penalizing firms with lower ESG scores. However, they reward those with good ESG scores.

According to the existing literature, studying the relationships between climate change and the financial sphere is significant.

### **3. Research Methodology**

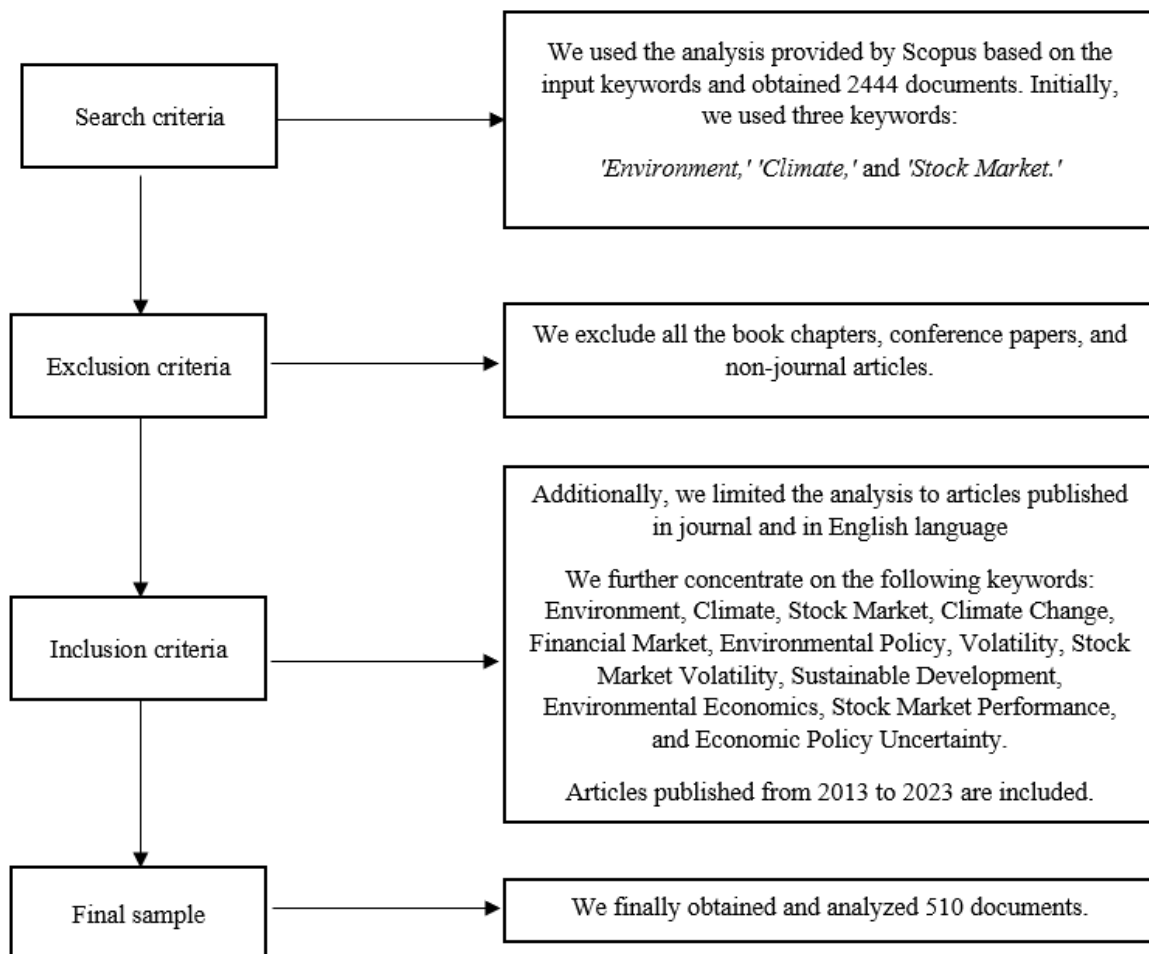
In this paper, we adopted a bibliometric analysis approach. Pritchard first used it in 1969 (Zhang et al., 2019). It is still widely used in various domains, such as economics, econometrics, business management, accounting and social sciences (Donthu et al., 2021; Kumari & Jaiswal, 2024; Lal et al., 2022). There has been a substantial surge in scientific research output in recent years. Consequently, researchers are facing an increasingly challenging task of staying abreast of relevant literature within their respective fields. To address this issue, bibliometric methods have emerged as valuable tools. It helps interpret and map the scientific knowledge of well-established fields. Additionally, they allow researchers to navigate the vast amount of scholarly data, identify influential works, and uncover the underlying structure of a field. Bibliometric analysis significantly advances scientific research

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<sup>1</sup> Titled of the article is 'Sustainable Finance in Emerging Markets is Enjoying Rapid Growth, But May Bring Risks' (2022) available on [www.imf.org](http://www.imf.org)

by introducing more objectivity into literature reviews. More specifically, the bibliometric analysis does not replace traditional review methods but complements them (Zupic & Čater, 2015). There are many bibliometric analysis tools, such as Vosviewer and Cite Space. Additionally, nowadays, Scopus also provides bibliometric data with basic graphs and tables. In this paper, we have used Scopus data for the bibliometric analysis and interpreted them while the keyword analysis map was created in the VOSviewer software. For the data extraction and inclusion-exclusion criteria, see Figure 1.

Research regarding climate finance has received significant attention from 2015 onward. In 2015, many actions were taken at the global level regarding climate change and sustainable development, such as the United Nations Sustainable Development Summit in New York held in September 2015 and the Paris Agreement on Climate Change held in December 2015. These actions significantly attract academicians and financial analysts towards sustainability and climate finance. So, we took two years before 2015 for better analysis as a base year, and at the time of analysis, full-year data is available till 2023. Hence, we have taken a time frame of ten years for the analysis.

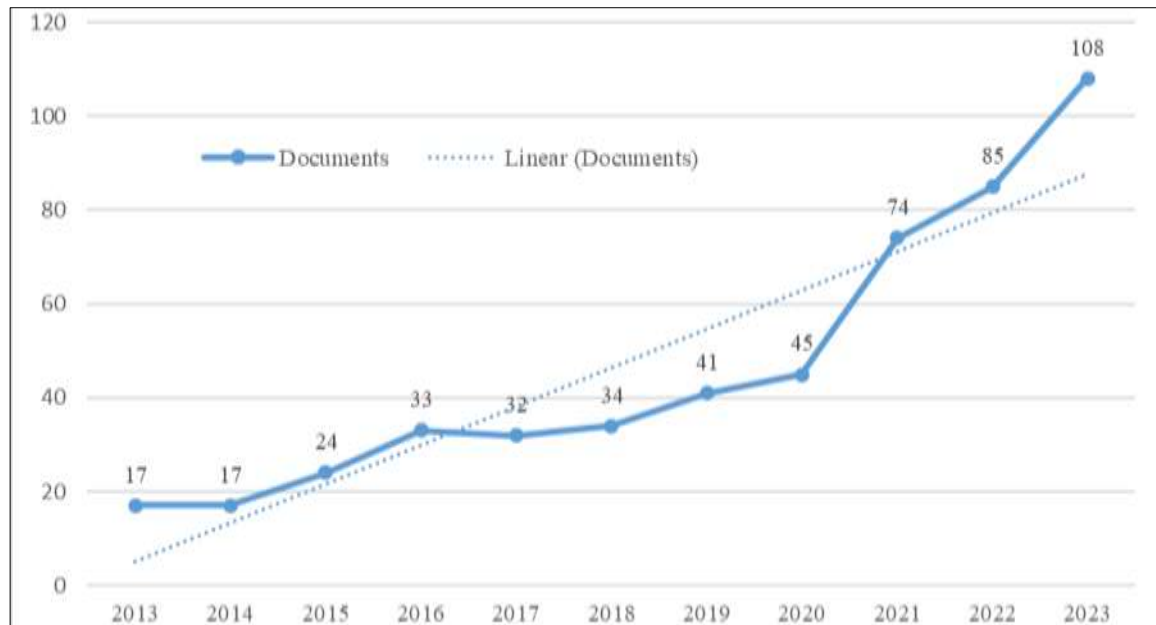


**Figure 1.** Inclusion-Exclusion criteria

## 4. Analysis and Discussion

### 4.1. Number of relevant Publications year wise

In this section, we analyze yearly publications in climate finance. Figure 2 shows the number of documents published from 2013 to 2023 in the field. It can be seen that the number of publications has increased at a normal growth rate till 2020, but after this year, the number of publications rapidly increased. Only 17 documents were published in 2013, but in 2023, the number increased by 108.



**Figure 2.** Number of relevant publications year-wise

**Note:** This figure represents the graphical presentation of several relevant publications related to climate finance from 2013 to 2023.

#### 4.2. Authors' region

This section examines the involvement of authors in the field of climate finance across various countries. Table 1 presents a list of 22 countries considered for analysis. We focus on countries with at least ten active authors in this domain. Consequently, only these 22 countries meet our inclusion criteria.

**Table 1.** Authors' region

Country	Documents	Rank
China	170	1
United States	61	2
United Kingdom	41	3
India	35	4
Germany	22	5
Canada	21	6
France	21	7
Malaysia	20	8
South Korea	19	9
Spain	19	10
Australia	18	11
Italy	18	12
Pakistan	18	13
Taiwan	18	14
Turkey	17	15
Saudi Arabia	16	16
Poland	12	17
Brazil	11	18
Netherlands	11	19
Viet Nam	11	20
Hong Kong	10	21
Portugal	10	22

Note: This table shows country-wise publications from 2013 to 2023. In this table, only those countries that have at least ten publications rest are excluded from the table. There are a total of 22 countries in this table.

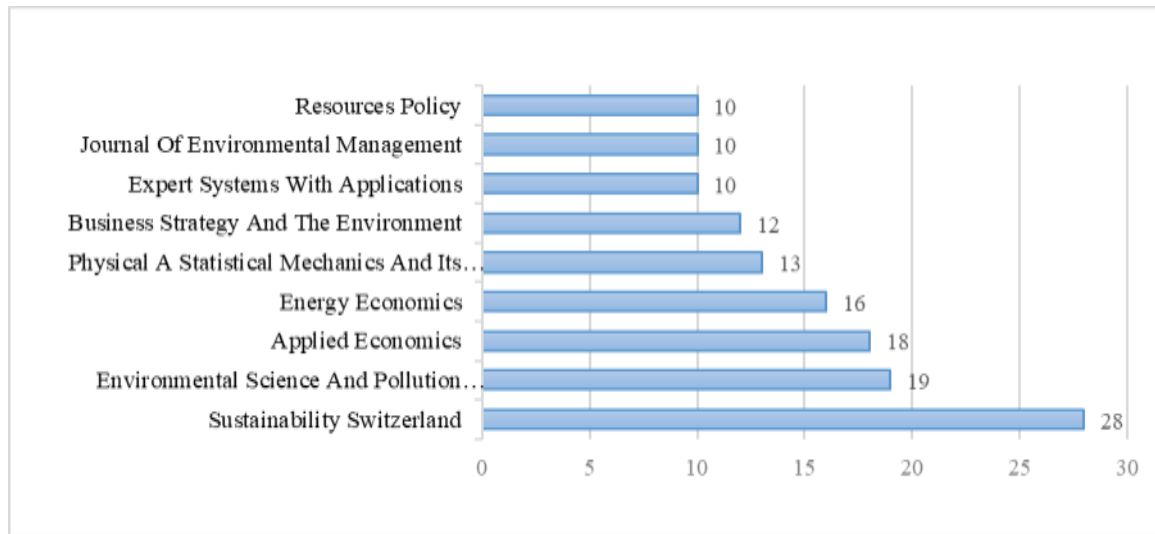
China emerges as the leader, occupying the top position. Notably, China's author participation surpasses any other country's by a significant margin. As depicted in Figure 2, China boasts 17 times more authors than Portugal, which ranks last in the list. The United

States and the United Kingdom are closely followed, and both trail behind China. Remarkably, the number of Chinese authors is approximately three times higher than that of the second-ranking country. Meanwhile, India secures the fourth position in this analysis.

#### *4.3. Sources of publications*

In this section, we focus on sources related to climate finance that meet the criterion of having a minimum of 10 documents within the field. Notably, the Switzerland-based MDPI's Sustainability stands out, leading the way with 28 publications during the selected period. Following closely is the Springer-based Environmental Science and Pollution Research journal, which ranks as the second most active journal in climate finance research.

Figure 3 visually represents the nine sources that fulfil the inclusion criteria for this analysis. The journals such as Resources Policy, Journal of Environmental Management, and Expert System with Applications are among the sources with the lowest publication count, each contributing only ten publications over time.



**Figure 3.** Sources of publications

**Note:** This figure shows the number of publications according to the sources of publications. We use the criteria of at least ten publications to choose the sources. According to the criteria, there are only nine sources in the table.

#### *4.4 Important Authors in the field*

After analyzing the active involvement of journals in this field now, it is significant to analyze the active involvement of the authors in the field. From the analysis, we found that the number of authors is large, but the number of documents published per author is not much more. Table 2 presents the list of 12 authors who have published at least three documents in the field of climate finance. None of these authors surpass the threshold of three publications. This finding underscores the need for further exploration and understanding of the factors influencing author productivity in this critical field.

#### *4.5. Subject Areas*

Numerous academic disciplines engage with climate finance. Table 3 highlights the top ten subject areas actively contributing to this field. According to the table, economics and related fields such as econometrics and finance lead the list, boasting the highest number of published documents. Interestingly, while climate change is inherently linked to environmental issues, environmental science ranks second in terms of document count. Specifically, only 148 documents have been published in this subject area from 2013 to 2023. Additionally, business, management, and accounting subjects exhibit a substantial presence, with 125 publications. In contrast, physics and astronomy have a notably smaller footprint in climate finance research.

**Table 2.** Important Authors

Author Name	Documents
Sami Ben Jabeur	3
Kun Guo	3
Rabeh Khalfaoui	3
Brian M. Lucey	3
María Ángeles López-Cabarcos	3
Zainuddin Abdul Manan	3
Mohamad Asrul Mustapha	3
Muhammad Ali Nasir	3
Victoria Paimanova	3
Juan Ramón Piñeiro Chousa	3
Muhammad Shahbaz	3
Yizhi Wang	3

Note: The above table shows the essential authors in this field. Authors who have at least three publications are part of this list. According to the criteria, there are only 12 authors in this table. These have an equal number of publications.

**Table 3.** Top 10 Subject areas

Subject Area	Documents
Economics, Econometrics and Finance	176
Environmental Science	148
Business, Management and Accounting	125
Social Sciences	103
Computer Science	98
Energy	80
Engineering	78
Mathematics	64
Decision Sciences	25
Physics and Astronomy	21

Note: The above table shows the top 10 subject areas that actively participated in the field of climate finance concerning publishing research papers

#### 4.6. Keyword analysis

This section delves into the most frequently used keywords within the field of climate finance. We set a minimum publication count criterion of 20 to identify these keywords. Table 4 and Figure 4 provide an overview of the keyword analysis. The keyword "*Stock Market*" is the most frequently used term in 303 documents. Interestingly, the top four keywords, "*stock market*," "*financial market*," "*commerce*," and "*investments*," all belong to the subjects of economics and finance. This observation aligns with our earlier discussion that the subject area of "*economics, econometrics, and finance*" is the most active in climate finance research.

In contrast, the corporate social responsibility keyword is not very popular in this field. Only 20 documents used this keyword in the selected period. The 'environment policy' keyword is also at the back seat of this field; it has only 21 documents. From keyword analysis, we may infer that researchers are more concerned with studying the stock market accompanied by climate finance. At the same time, environmental policy and corporate social responsibility receive comparatively less attention.

#### 4.7. Citation analysis

This section analyses the most cited papers, accompanied by the number of citations, year of publication, journal, and authors. Citations may be considered as a measure of influence. If an article has more citations, it is considered an influential article. Table 5 demonstrates the top ten cited papers based on the number of citations until January 31, 2024. As we considered the top ten cited papers based on the number of citations, the most recent documents are, by default, excluded from the list. According to Table 5, the document titled '*Financial Development and Environment Quality: The Way Forward*' from the journal 'Energy Policy,' published in 2016, is the most cited paper in this field with a count of 316 citations.

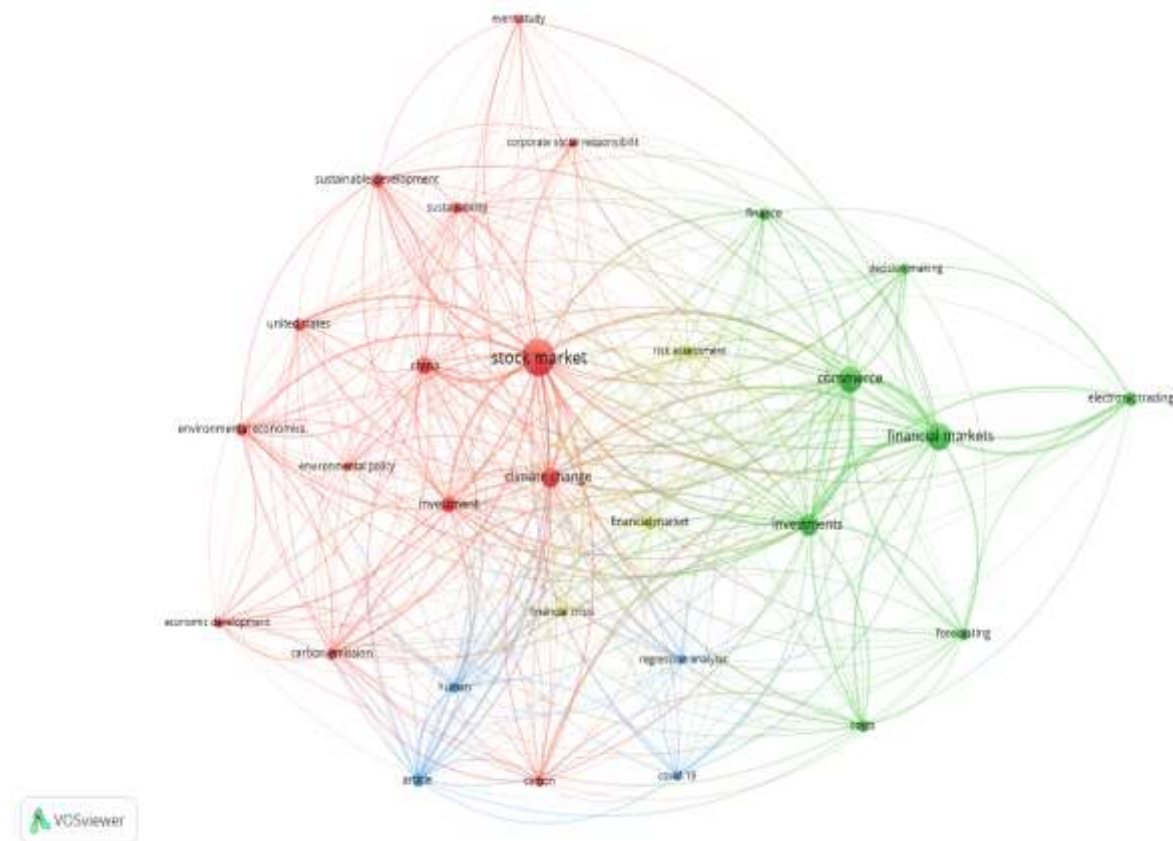


This paper is written by three authors named 'Shahbaz M., Shahzad S.J.H., Ahmad N., and Alam S.' The second most cited paper was published in 2017 in the journal '*Business Strategy and The Environment*.'

#### Table 4. Keyword analysis

Keyword	Documents	Keyword	Documents
Stock Market	303	Financial Market	35
Financial Markets	173	Forecasting	34
Commerce	159	United States	33
Investments	118	Decision Making	32
Climate Change	91	Risk Assessment	29
China	67	Carbon	27
Investment	61	Human	26
Sustainable Development	47	Sustainability	26
Electronic Trading	44	Economic Development	24
Environmental Economics	40	COVID-19	22
Article	37	Event Study	22
Costs	37	Financial Crisis	22
Finance	36	Environmental Policy	21
Carbon Emission	35	Corporate Social Responsibility	20

Note: The above table shows the number of publications according to the keywords. In this table, those keywords with at least 20 publications are considered. Twenty-eight keywords meet the criteria.



**Figure 4.** Keyword map

#### 4.8. Co-Citations of Documents

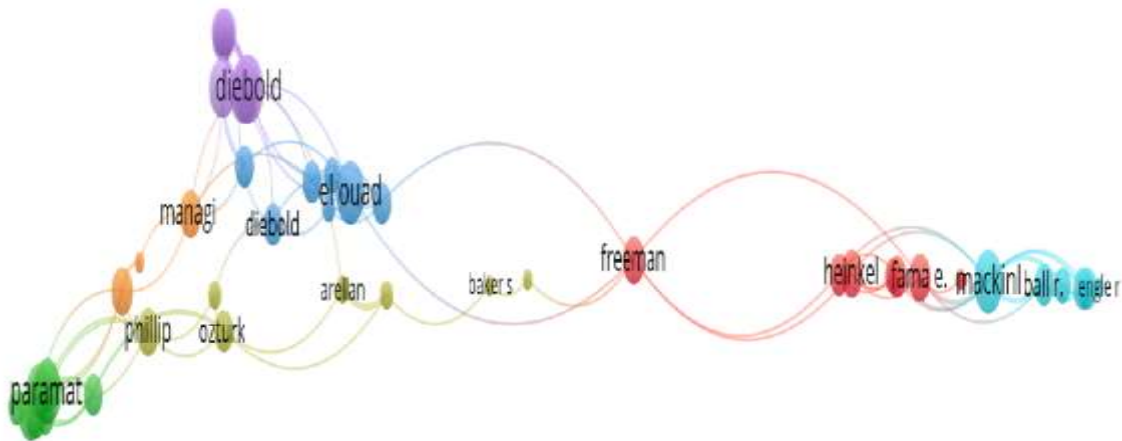
Co-Citation of documents helps to understand the thematic and conceptual connection between two or more documents. For example, if another paper commonly cites two papers, it means both cited papers have conceptual or thematical connections with each other. In Figure 5, the co-citation map shows the seven clusters according to the co-citations of papers. Each

cluster holds a different count of papers. Different colors on the map represent the different clusters.

**Table 5.** Top ten cited papers

Document Title	Journal Title	Total citations	Citations
Financial development and environmental quality: The way forward	Energy Policy	316	(Shahbaz et al., 2016)
Too Little or too much? Exploring U-shaped Relationships between Corporate Environmental Performance and Corporate Financial Performance	Business Strategy and the Environment	286	(Trumpp & Guenther, 2017)
Climate risks and market efficiency	Journal of Econometrics	203	(Hong Frank Weikai Li Jiangmin Xu et al., 2016)
Environmental degradation & role of financialization, economic development, industrialization and trade liberalization	Journal of Environmental Management	167	(Nasir et al., 2021)
Non-state governance and climate policy: the fossil fuel divestment movement	Climate Policy	143	(Ayling & Gunningham, 2015)
A hybrid ANFIS model based on empirical mode decomposition for stock time series forecasting	Applied Soft Computing Journal	142	(Wei, 2016)
Effects of financial development on energy consumption: The role of country risks	Energy Economics	135	(Chiu & Lee, 2020)
Carbon emissions determinants and forecasting: Evidence from G6 countries	Journal of Environmental Management	134	(Nguyen et al., 2021)
Environmental, social, and governance reporting in China	Business Strategy and the Environment	133	(S. Zhou, 2016)
Forward Forecast of Stock Price Using Sliding-Window Metaheuristic-Optimized Machine-Learning Regression	IEEE Transactions on Industrial Informatics	125	(Chou & Nguyen, 2018)

Note: This table shows the top 10 cited documents till January 31 2024.



**Figure 5.** Co-Citation of Documents

## 5. Discussion

The above analysis shows that climate change is attracting the attention of academicians, investors and regulators worldwide. The trends in studying climate change are rising, linking it with stock markets. China played a very active role in conducting these studies, and the United States and the United Kingdom followed them. Notably, the Switzerland-based MDPI's *Sustainability* stands out, leading the way with 28 publications during the selected period. Following closely is the Springer-based *Environmental Science and Pollution Research*

journal, which ranks as the second most active journal in climate finance research. Although climate change is generally related to the environment field, economic and theory-related fields such as Econometrics and Commerce are actively involved in studying climate change and linking it with stock market performance. Interestingly, while climate change is inherently linked to environmental issues, environmental science ranks second in terms of document count. As we have discussed, the economic field leads in this domain, and then obviously keywords related to this field lead the list, such as '*Stock Market*' and '*Financial Market*'. Generally, two theories are used in this field: the Signaling Theory and the Efficient Market Hypothesis (Lemma et al., 2019; L. Y. He & Liu, 2018). According to the Signaling theory, various market signals and patterns indicate the initiation of trades or positions. In contrast, the Efficient Market Hypothesis refers to stocks reflecting all the available market information.

## **6. Conclusion**

This paper analyses climate change from a financial perspective and uses a simple bibliometric approach. It considered only journal articles between 2013 and 2023 to limit the study period. We may understand the subject matter through visualization illustrations and ranking analysis of many factors based on a sample of 510 relevant publications. We can see the upward trends in the number of publications year by year in the sample period. Based on the author's region analysis, China occupies the top position in terms of maximum author participation in the domain. Followed by the United States and the United Kingdom. Whereas papers related to this field are mainly published by 'Switzerland-based MDPI's *Sustainability*,' '*Environmental Science and Pollution Research*,' and '*Applied Economics*,' but are scarcely seen in other environmental, financial, and economics journals. When we analyze the subject area covered by documents related to this field, we find that economics and their subsequent fields, such as econometrics and finance, are aggressively active in studying climate change instead of any other environmental-related subject area. According to the keyword analysis, stock market and financial market are the most frequently used words in this field. We also analyze the most cited publications in this field and document the top ten cited publications in this paper. This paper will provide a compilation of finance and climate change relationships for academicians, researchers, and policymakers.

## **Declaration of Conflict of Interest**

The authors affirm that no conflicting financial or personal interests could have impacted the findings of this paper.

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