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Article

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A bibliometric analysis on the research trends of global climate change and future directions

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ABSTRACT

This paper uses bibliometric methods to quantitatively analyze global scientific performance and current research fields in the field of global climate change. The intention was to enhance knowledge of the scientific understanding of climate change. The data used in this analysis is based on 259 papers by scholars worldwide that were published in 498 academic journals in the Scopus database between 2006 and 2022 to investigate the methods used in scientific research to study climate change. The scientific knowledge, changes in research hotspots, worldwide geographic distribution of research, and country-specific focus are all summarized in our analysis. The findings indicate that (1) Throughout the era under investigation, the goal of research on climate change has evolved from comprehending the climate system to developing climate technology and regulations, like laws and efficient energy use; (2) The idea of climate change is reflected in modern models of energy efficiency, renewable energy transition, carbon pricing, and circular economy. The idea of climate change, seen from an overall viewpoint, affects carbon footprint, social and economic impact, rising carbon dioxide levels, and carbon sequestration; (3) since 2006, research on climate change vulnerability has grown rapidly, and its publications are widely disseminated in numerous source journals; in terms of global climate research change, the Chinese Academy of Sciences and the University of Chinese Academy of Sciences are the two most productive institutions and Water resource-related disputes and collaboration. Our research can be used by scholars and policymakers to investigate future research goals and to consider the current directions of climate change studies. Future studies can address issues related to human health risks, inequality in society and the economy, policy and regulation in the context of global climate change, and the rate at which emissions will zero out. This study's primary goal is to close this gap and improve our comprehension of the body of current literature.

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1. Introduction

Since the Industrial Revolution, there has been a 25% increase in atmospheric concentrations of carbon dioxide due to the combustion of fossil fuels and significant deforestation (Woodwell, 1989). Although environmental scientists disagree greatly about the extent of the climate change that greenhouse gas accumulation is expected to cause (Ahmed & Turchini, 2021; Schneider, 1989, Schneider, 1990), they all agree that the Earth's surface is warming more quickly than before (Li et al., 2020a; Schneider, 1990, Schneider, 1994; Watson et al., 1996). The world's need for energy will undoubtedly continue to climb due to economic development and the world's population growth, which is expected to reach around 7.7 billion people by 2019 (Nguyen et al., 2020) and maybe 9.7 billion by 2050 (Alam et al., 2021; Ibrahim et al., 2022; Li et al., 2020b). The rise in atmospheric carbon dioxide has consequences for Earth's photosynthetic activity concurrent with the impacts of global warming (Allen & Amthor, 1995). The development and execution of a legislative and policy framework to guarantee financial stability was the focus of a 2018 study by Durmaz. This will help to increase investors' trust in taking part in CCS projects.

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Global energy demand rose by 2.1% in 2017, with fossil fuels accounting for roughly 81% of all energy consumed. As a result, in 2018 a record-breaking 33.1 Gt of CO₂ emissions were recorded (Ebi et al., 2021; Lange, 2019; Solano-Olivares et al., 2019). Furthermore, the buildup of CFCs and other compounds that are chlorinated and brominated is causing the stratosphere's ozone layer to thin, increasing the amount of ultraviolet (UV) radiation that reaches the surface of the Earth (Ekundayo & Okoh, 2018; Smith et al., 1992; Worrest et al., 1989). Considerable attention has already been paid to the potential impacts of a changing global climate on terrestrial plant communities, both in agriculture and in the natural world (Alatawi et al., 2023; Mueller-Dombois, 1992; Tian et al., 2012).

On the other hand, the potential impact of climate change on aquatic plant communities—including seagrasses—has received very little attention (Alhossini et al., 2021; Bijlsma et al., 1996). Over the past ten years, climate change has also grown to be a significant political, economic, and environmental issue as well as a major topic of discussion in public and political forums. Climate change (CC) is a multifaceted, intergovernmental issue that affects many aspects of the ecological, environmental, socio-political, and socio-economic fields on a worldwide scale (Adger et al., 2005; Anderegg et al., 2010; Fang et al., 2018; Feliciano et al., 2022; Leal Filho et al., 2021; Lima & Bonetti, 2020; Nájera-Sánchez, 2019; Roostaie et al., 2019; Zyoud & Fuchs-Hanusch, 2020). The Earth's oceans will be greatly impacted by the accelerating rate of global climate change that has been observed this century and is expected to continue into the next. The productivity, distribution, and function of plants will change as a result of both direct and indirect consequences of global climate change. Environmental security-related issues have drawn more attention throughout time. The academic community has been studying climate change and carbon sinks extensively in recent years, and a wealth of pertinent research findings have surfaced. Temperatures are rising on many different worlds due to climate change (Fu et al., 2018; Statista, 2020; Yadav et al., 2015; Geng et al., 2020). The earth's climatic crisis became much more acute with the start of the industrial revolution (Leppänen et al., 2014; Manyena et al., 2019; Peduzzi et al., 2012). Comprehensive long-haul temperature and precipitation patterns, as well as additional factors like atmospheric pressure and humidity, are used to characterize climate change. In addition, the most well-known local and worldwide repercussions of climate change are the rising sea level and the erratic weather patterns caused by the disappearing global ice sheets (Garrigos-Simon et al., 2018; Lipczynska-Kochany, 2018; Lu et al., 2022; Michel et al., 2021; Murshed et al., 2020; Ponce-Reyes et al., 2012). The century-scale increase in the average temperature of the earth's surface is known as 'climate change' or 'global warming.' According to the Intergovernmental Panel on Climate Change (IPCC) preface, 'the IPCC is now 95 percent certain that humans are the main cause of current global warming (Anderegg et al., 2010; Anser et al., 2020; Martín-Martín et al., 2018).

In the natural sciences and, more recently, the social and political sciences, there has been a marked increase in the focus on climate change. Scientists are actively working to use theoretical models and data to forecast the future climate and to understand the past climate. When considering extended periods of time, a wide range of factors contribute to climate change, including changes in solar radiation, which alter the parameters of the earth's orbit and the sunspot number, drifting continents, volcanic eruptions that produce large amounts of sulfate-based aerosols, etc. Due in large part to the engagement of multinational initiatives like the Paris Agreement and the Intergovernmental Panel on Climate Change, global climate change is receiving a great deal of scientific, political, and public attention. The Intergovernmental Panel on Climate Change (IPCC) has released its fifth assessment report, which notes that many aspects of climate change and its related influence will persist for several centuries even if humans stop emitting greenhouse gases (Bahadur et al., 2013; Pachauri, 2014). This means that the impact of climate change has already 'locked in,' making it difficult to mitigate the effects of climate change in the near term (United Nations Framework Convention on Climate Change, 2020a). Thus, adaptation is a given regardless of how hard people try to cut emissions, manage the risk of climate change, and mitigate its already-occurring negative effects. The more practical and urgent issue at hand right now is how to actively adapt to climate change as opposed to implementing mitigation strategies. In Wang et al. (2014) quantitative analysis of the literature's development trend in the related field of climate change vulnerability, they found that issues with water resource management, food safety in agriculture, and socioeconomic system health were currently the most talked about in the vulnerability research field.

Wei et al. examined model techniques and research hotspots in the field of climate policy modeling using a bibliometric approach, based on the SCI-E and SSCI databases. To sum up, the following are the ways in which this study advances the state of the field (NASA, 2020): (1) By evaluating the research trends in the area of climate change adaptation, we fill in the gap left by no one else. (2) Based on the analytical results of this study, potential research directions and constraints are inferred, which will provide direction for future research planning and execution. Based on keyword frequency and co-occurrence analysis, we explore the most popular subjects related to adapting to climate change as well as possible evolutionary patterns in this field. Climate change research has been explored multiple times with bibliometric methodologies, ever since its inception, during the '90s (e.g. Schwechheimer & Winterhager, 1999). The result that has received the greatest attention in the literature is the sharp increase in publications, which has been accompanied by a rise in co-authorship, international collaboration, and interdisciplinarity (Baker et al., 2021; Grantham Research Institute on Climate Change and the Environment, 2019; Grieneisen & Zhang, 2011; Haunschild et al., 2016; Stanhill, 2001). While topic-specific evaluations are frequently used to evaluate the state of the art in particular research fields, there aren't many comprehensive overviews of the field of climate change research. A few recent examples include summaries of studies on carbon sinks (Boyd & Juhola, 2015; Huang et al., 2020) and the relationship between infectious diseases and climate change (IPCC, 2021; Li et al., 2020; United Nations Framework Convention on Climate Change, 2020b). Aims to define the intellectual landscape in this field by pointing out and disclosing its fundamental traits, research strength, intellectual foundation, evolution of research topics, and research hotspots. As a crucial quantitative analytic technique, bibliometric analysis has been applied extensively in many different domains and is capable of accurately describing the general trend of a subject's or field's development (Busayo & Kalumba, 2020; Butler et al., 2021; Labeodan et al., 2016; Marrone, 2020). A real-world problem endangering human and animal existence is the influence of climate change, which makes economies vulnerable.

2. Literature review and theoretical Framework

2.1. Studies on climate change

Since the 1970s, climate change has gained relevance and will likely garner significant attention from academics in the ensuing decades. The number of studies on climate change has doubled every five to six years, indicating the rapid growth of the field (Haunschild et al., 2016). In the past ten years, the most thorough bibliometric evaluations examining research on climate change have been created. Grieneisen & Zhang (2011) examined a pool of 110,139 publications published between 1997 and 2009 using a comprehensive keyword selection specific to climate change research. The authors emphasized how the field's publishing rate had rapidly increased in the first 2000s and showed the frequency of climate change publications with respect to the 253 subject categories and the 10 major Web of Science categories. They also listed the world's most prolific institutions. Based on the online Science Citation Index Expanded between 1992 and 2009, Li et al. (2011) looked at 41,457 papers on climate change. Zhao & Li (2015) gathered 113,468 publications from 1993 to 2012 on environmental assessment (EA), which is a more general field of study that includes climate change. They then described productivity patterns along a number of dimensions, such as assessing the research performance of the most productive nations, important subject areas, and journals that are most representative of the field. Pasgaard & Strange (2013) examined the disparity in the availability of climate change knowledge between wealthy and developing nations, drawing on 15,000 publications from 1999 to 2010. Their findings indicated a notable imbalance in the availability of climate change knowledge across resource-rich and impoverished environments, as well as the existence of conflicting concerns. Haunschild et al. (2016) examined 222,060 articles and reviews from 1980 to 2014 on Web of Science. They noted a robust increase in macro-fields such as natural sciences, medicine, and engineering, as well as seven climate sub-systems like oceanic water and atmosphere. Additionally, they provided descriptive statistics on the total publication outputs for 32 countries. Using a large sample of over 400,000 climate change-related publications (up to 2018), Callaghan et al. (2020) selected 140 topics on climate change research. They next looked into the over- and underrepresentation of research topics in the reference list of IPCC reports.

A descriptive study of 120,000 articles from 2011 to 2018 was carried out by Fu & Waltman (2022), who also applied a term mapping and burst detection analysis (limited to a sub-set of 25,000 articles) to give an overview of the field's work on climate change and insights into its development. The analysis was concentrated on five clusters of research areas (physical sciences, paleoclimatology, climate change ecology, climate policy) and focused on the eight most prolific countries. Numerous bibliometric assessments have been undertaken to analyze certain areas of climate change research. These range from studies that aim to review the current state of climate science in relation to particular domains, such as adaptation, vulnerability, and resilience, and specific areas, such as geoengineering and tourism (Janssen & Ostrom, 2006, Belter & Seidel, 2013; Wang et al., 2014, Aleixandre-Benavent et al., 2017, Wang et al., 2018, Rana, 2020); the analysis of collaborative research patterns in the field (Engels & Ruschenburg, 2008; Jappe, 2007; Sangam & Savitha, 2019); the comprehension of climate change controversies (Cail & Criqui, 2021; Jankó et al., 2014, 2017); the comprehensive examination of the performance of single target journals, such as *Climate Change* and *The Bulletin of the American Meteorological Society* (Stanhill, 2001, Hellsten & Leydesdorff, 2016). Science-related sociologists and economists have investigated what motivates scientists to conduct research, including what to research. Their findings have highlighted the significance of various motivational types, including extrinsic motivations, prosocial motivations (Blaise et al., 2017; Carlo et al., 2024; Sormani & Uude, 2022) and intrinsic motivations (Chen et al., 2020), such as the satisfaction of solving puzzles and receiving recognition from peers for being the first to make a scientific discovery. According to recent research, for instance, people's environmental worries were heightened by climate change disasters, which influenced their voting patterns and led to a rise in support for green parties (Chen et al., 2022; Hoffmann, 2022). Braunschweiler & Ingold (2023) provided another example demonstrating how perceived danger and extreme occurrences influence the creation of local adaption strategies.

3. Research methodology

This study's research design is an exploratory longitudinal literature review that made use of bibliometric and historical trend analysis. At the micro, meso, and meta levels, the study has quantitatively examined worldwide research patterns. The host institution's subscription provided access to the Scopus database, which contained the publications used for analysis. The study examined research publications that were published on three different topics: (1) climate change resilience, (2) catastrophe resilience, and (3) combining climate change and disaster resilience. Keyword, citation, institution, and country analyses were among the data analysis techniques used. The results were visualized using the open-source program VOSviewer.

3.1. Data gathering

Researchers looking for studies on global climate change conducted a thorough search of the scopus database. Utilizing the chosen keywords, the topic search field was employed. The author's keywords, the abstract, and the title are all searched for in the topic search. The search criterion was not restricted by an expiration date. However, based on keywords, the oldest article was published in 2006. Consequently, it is reasonable to presume that research articles were taken from the 2006–2022 timeframe. On March 2, 2023, a database search was conducted. To be used subsequently, every record was exported in its entirety, complete with cited references, into a text file with tabs delimited. Publication details such as the title, authors, year of publication, abstract, source title (journal name), affiliation, author's keywords, subject categories (disciplines), language, and the quantity of citations (if any) were all included in the full record and cited references. Since there was only one database used, there was very little possibility of repetition. Furthermore, the study results were verified using the online tool 'Analyze Results' from the scopus website. The complete record and referenced references contained published details such as the title, author(s), year of publication, abstract, affiliation, author's keywords, subject categories (disciplines), and number of citations (if any) for each piece. There was very little possibility of recurrence because only one database was used.

3.2. Techniques for analyzing data

In order to analyze the resilience argument in the context of global climate change, this study used descriptive statistics. The research has employed four distinct analyses. (1) To comprehend the temporal pattern of research on catastrophe and climate change resilience, historical analysis was done. (2) In order to comprehend the nature, connections, and thoughts employed by the authors, a keyword analysis was done for the author's keywords. In order to save space, the phrase 'keyword' will be utilized. Maps showing the major cooccurrence terms were created using VOSviewer. To make the terms in the figures easily accessible and understandable, the co-occurrence restriction was used. To determine the quantity of citations a specific article has, citation analysis was carried out. To find the most active countries and organizations publishing on resilience, analyses of institutions were carried out. We utilized VOSviewer for keyword analysis and Mendeley Desktop for records and referencing. This is how the research's conceptual framework looks in [Figure 1](#).

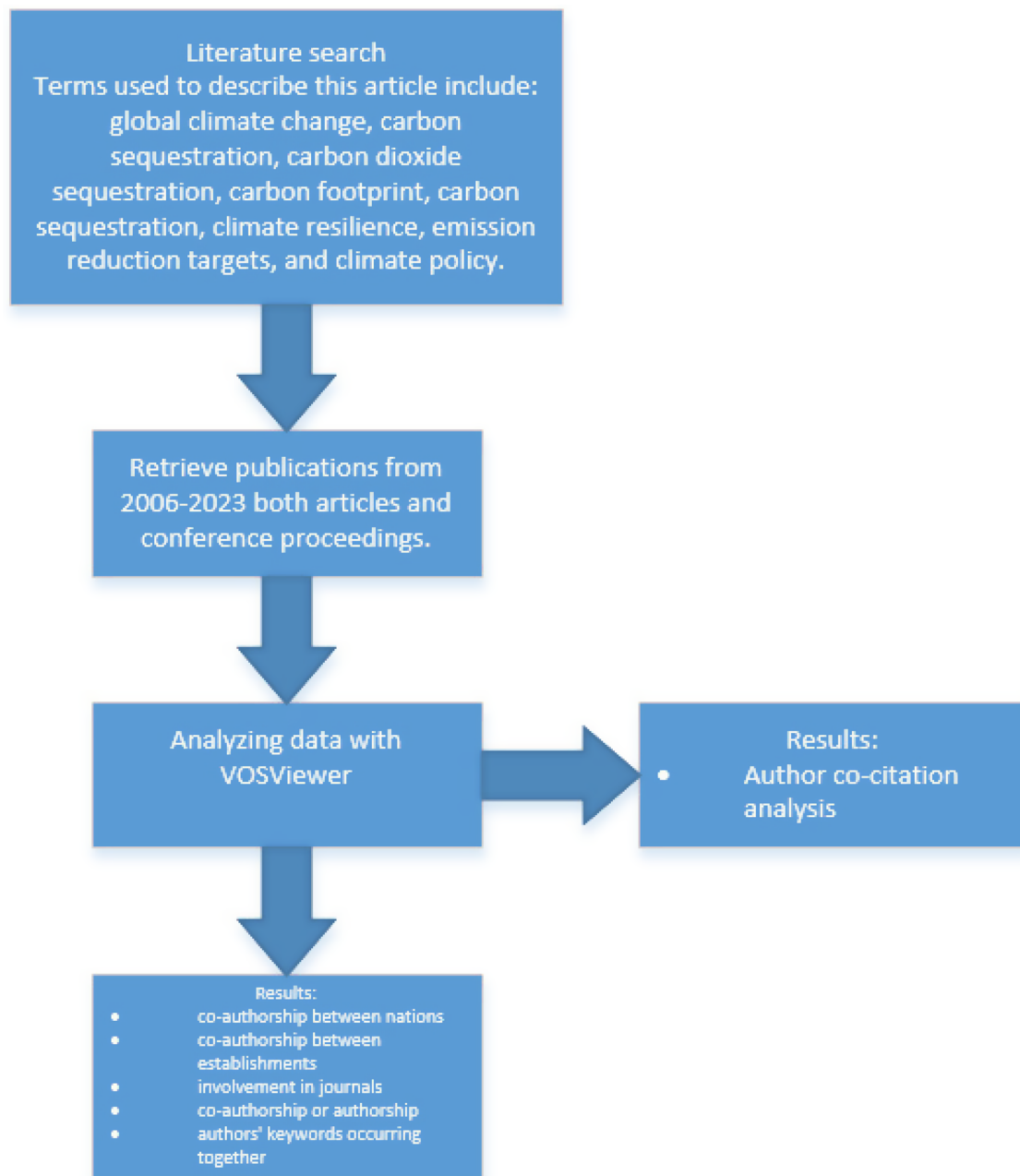


Figure 1. Research's conceptual framework.

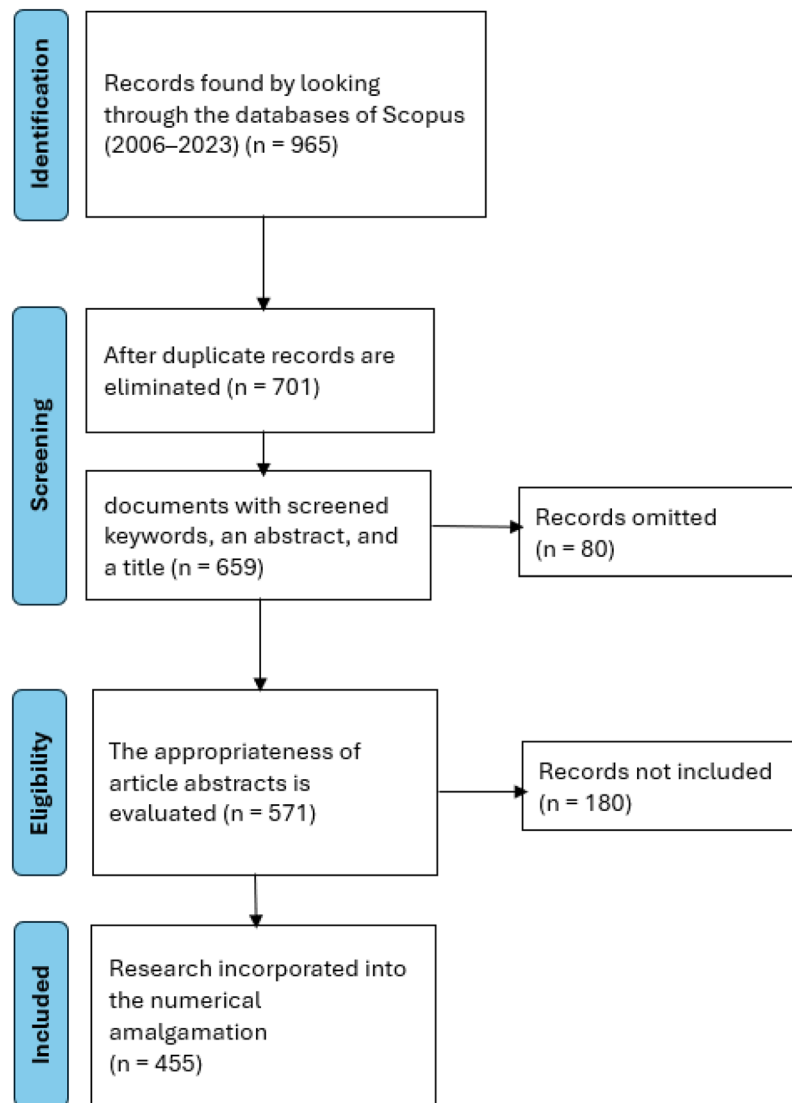


Figure 2. Inclusion and exclusion criteria and the process leading to the selection of these number of papers.

Inclusion and exclusion criteria and the process leading to the selection of these number of papers can be seen in Figure 2.

4. Result and discussion

4.1. A Bibliographic examination

A quantifiable research method known as ‘bibliometric analysis’, it entails examining patterns and trends in published literature through the use of a variety of bibliometric indicators, including journal impact factors, authorship, coauthorship, and citation counts (Constantinidou et al., 2019; Donthu et al., 2021). According to Chabowski et al. (2013), the goal of the bibliometric study is to classify emerging trends and gaps in the literature while providing a rigorous and objective assessment of the impact and influence of scholarly research. Citation data is a major component of bibliometric study; yet, citation patterns are subject to bias. However, these analyses might fall short of capturing the significance of transdisciplinary research, which is increasingly prevalent (Blennow & Persson, 2009; Cubie & Natoli, 2022; Xu et al., 2021). This section is organized in accordance with the previously mentioned review protocol. Following the bibliographic analysis, we provide an explanation of the publication’s history. Lastly, we highlight relevant terms relating to global climate change and explain their

meaning. Effective teamwork is a critical component of academic advancement. One of the most noticeable traits is the growing cooperation in scientific study across a range of levels or domains (de & Price, 1963). One frequent metric used to gauge how closely scientists collaborate on research projects is the degree of academic collaboration (Wei et al., 2014). Here, we present the level of scholarly cooperation in the area of adaptation to climate change from three perspectives: authors, institutions, organizations and nations. We have used the Scopus database to analyze the bibliometric analysis of research linked to selenium in agroecosystems during the previous 18 years. The bibliometric analysis approach is shown in Figure 1 to help discover research gaps and possible research fields. The study was conducted using the bibliometrics and bibliophily packages available in the R environment (Aria & Cuccurullo, 2017).

4.2. Global research output on climate change throughout time

Figure 3 illustrates the annual total number of scientific publications on climate change worldwide from 2006 to 2023. It demonstrates the exponential growth in the number of scholarly articles on climate change.

From Figure 3, indicate that 2023 saw 166 papers on global climate change research, followed by 111 in 2022 and 64 in 2021, which accounted for the third-highest number of publications. In the 20s, the top 10 countries produced more than 60% of the new literature on climate change; by 2023, that number had increased to more than 70%. This indicates that the scientific output has become more diversified over time.

4.3. Bibliometric coupling by publication

The idea behind bibliometric coupling is to assess and quantify the relationships between researchers, scientific publications, and research organizations through the application of bibliometric analysis. By examining how closely a publication relates to other publications based on its number of publications or coupling with top works, bibliometric coupling based on publications has the advantage of assisting in the identification of networks of collaboration between researchers, academic institutions, and research institutions. It also provides an evaluation of the impact of research. Bibliographic coupling Coupling by Sources can be seen in Figure 4 as follows:

Co-citation analysis of highly-cited references used in integrated resilience publications (with a minimum of 35 citations).

4.4. Distribution of productive journals

When it comes to writing, research, and information production, source-based published documents are especially advantageous. Source-based published papers have several advantages, such as assisting readers or researchers in tracking down the original source of information, analyzing research technique, and conducting additional analysis on the data utilized. Resources serve as a foundation or point of departure for future study, which can stimulate more research. Publication documents by sources can be seen in Figure 5 as follows:

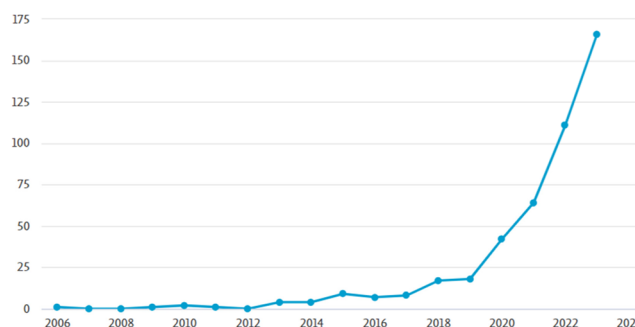


Figure 3. The annual total number of scientific publications on global climate change.

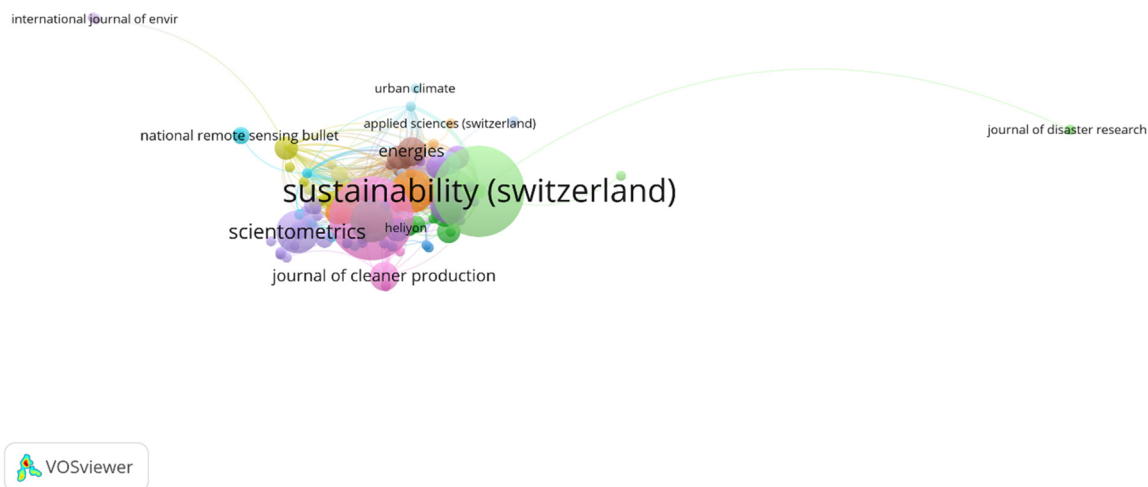


Figure 4. Bibliographic coupling Coupling by sources.

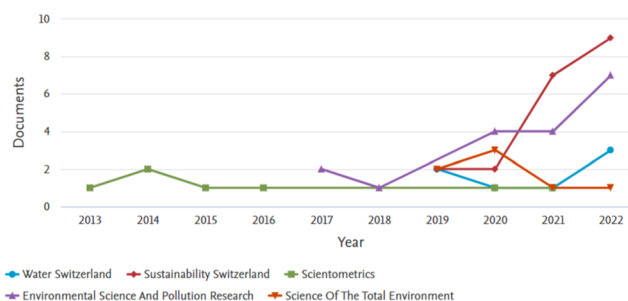


Figure 5. Publication documents by sources.

Data was collected from 259 academic papers where 150 sources/journals on this subject using the Scopus database. By examining the papers published in the top 10 productive journals, patterns in the rise of their publications are identified. The sustainability Switzerland has published 20 documents on global climate change, while environmental science and pollution research have published 18 papers on the same topic with 150 sources. These are the most significant. Global Climate Change: Seven Documents Published by Science of the Total Environment, Scientometrics, and Water Switzerland.

Figure 6 show that the most productive author in global climate change are Janssen M. A; Schoon M.L and Zhang d; Zhang Z; Managi S. Bibliographic coupling based on global climate change research documents has a number of significant benefits in understanding, measuring and evaluating the impact and development of research helping to map networks of researchers involved in global climate change research, helping to identify collaborations between researchers, institutions and countries.

4.5. Network visualization co authorship by countries

The quantity of publications is a crucial metric for evaluating the direction of progress in a given area; to some degree, the quantity of documents from a particular nation in this sector can be interpreted as a measure of that nation's strength in research.

Research has shown that climate change is a crucial notion in relation to natural hazards, social-cological systems, and global environmental change.

In addition to being an extremely interdisciplinary endeavor, research on climate change involves collaboration and activity from numerous nations. Figure 7 show that the most productive countries in global climate change research are China, Spain, Italy and Australia.

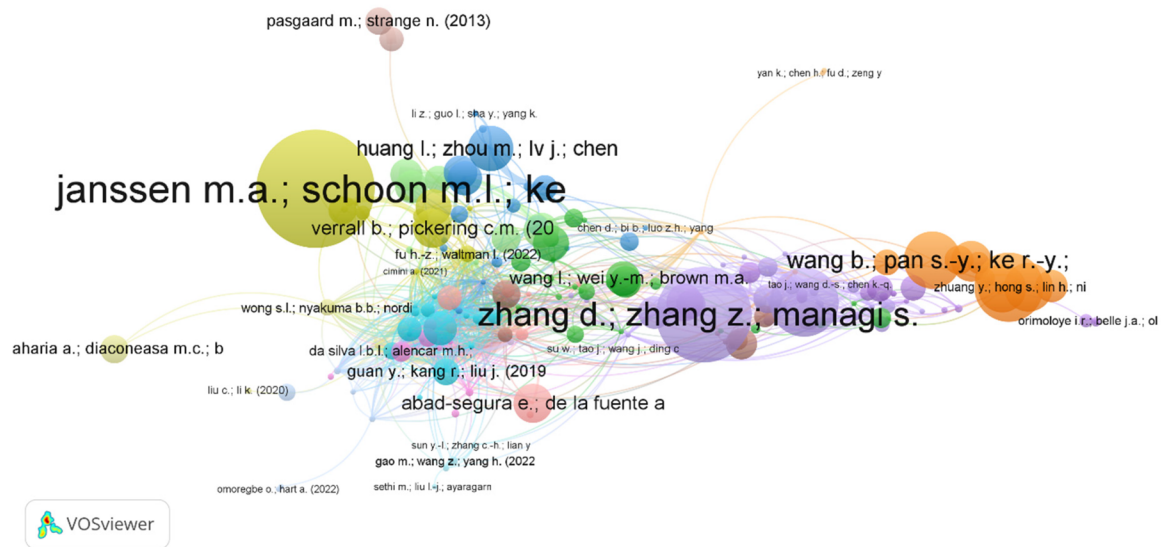


Figure 6. Bibliographic coupling Coupling by publication of global climate change research.

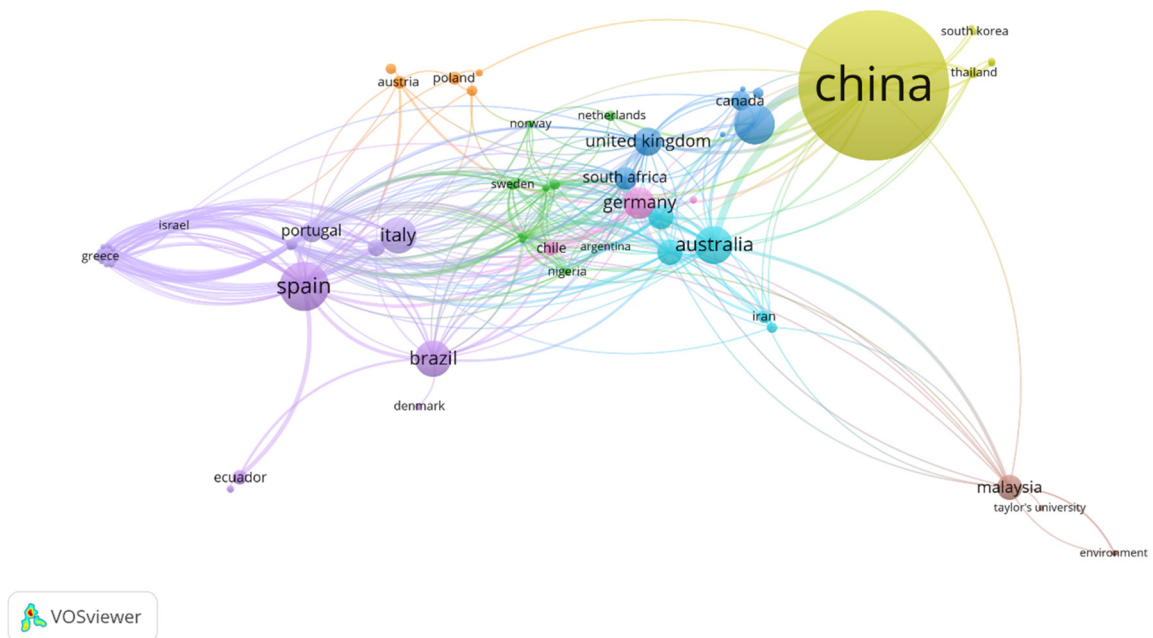


Figure 7. Network visualization co authorship by countries.

4.6. Time-evolution graph of study subjects

Map of global climate change of author's keywords (50 co-occurrence criteria with 32 Keywords) 2006-2023 can be seen in in [Figure 8](#) as follows:

Global perspective, remote sensing, and climate change are the most prominent title words of the publications published between 2006 and 2023. [Figure 8](#) show that: Co-Occurrence by index keywords of global climate change research are climate change, remote sensing, global perspective, global change and groundwater.

Academic scholars and international governments have expressed serious concerns about the effects of climate change. To find journal papers related to global climate change, the Scopus databases were used. Using bibliometric and visualization tools 'Biblioshiny' and 'VosViewer', the final data from 259 journal articles were examined for science mapping and bibliometrics analysis, are two often utilized software applications. It was wanted to trace the status and trends of these research efforts back to their

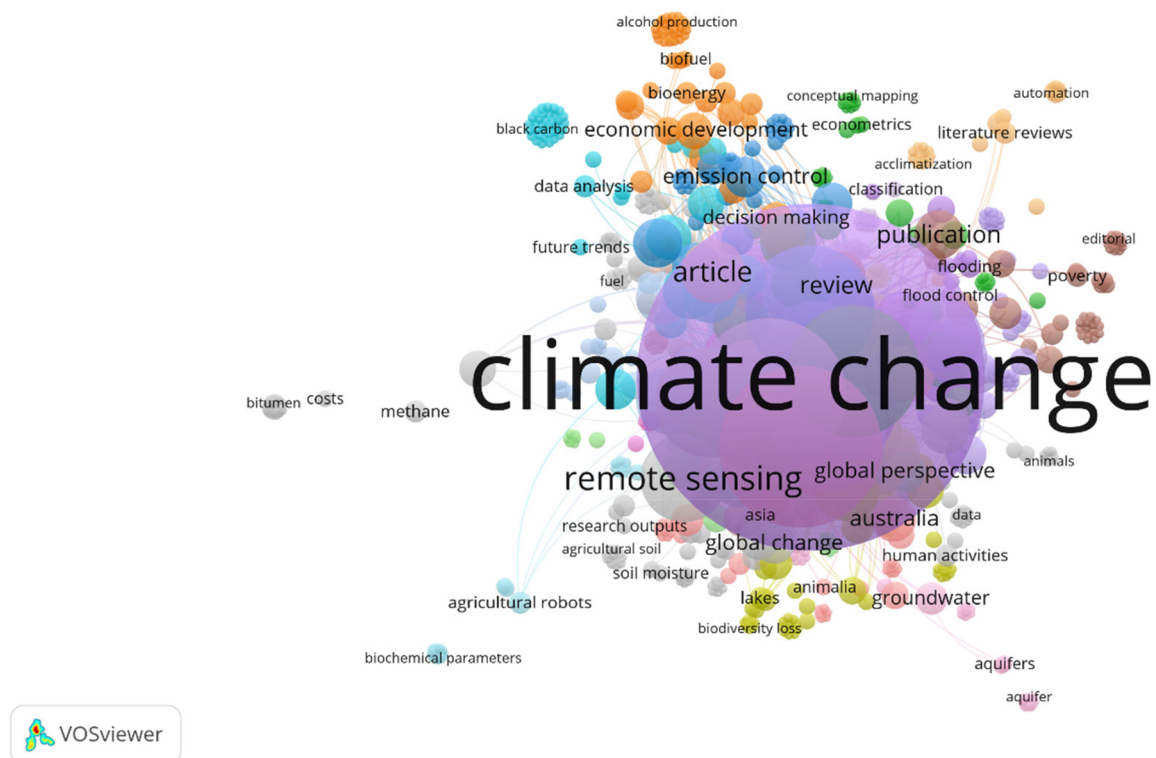


Figure 8. Co-occurrence by index keywords of global climate change research.

source by bibliometric analysis. A related point brought out by this study is that bibliometric overviews that solely take into account the nations with the highest level of scientific production and/or the most prominent topical trends run the danger of failing to account for the uneven geographical distribution of the themes. These could consistently undervalue the significance of research fields centered in less producing nations and ignore the unique and varied research interests of many emerging nations (D'Orangeville et al., 2018; Pasgaard & Strange, 2013). This topic is especially significant for research on climate change since global initiatives must take into account the difficulties experienced by nations with relatively low scientific production. For instance, prior studies have demonstrated that the number of developing nations represented among IPCC reviewers is notably low (Palutikof et al., 2023). Lastly, this study serves as an illustration of the potential advantages that newly created scientometric research methodologies may have for mapping the body of scientific literature, particularly in large and quickly expanding topics like research on global climate change.

Using the most popular phrases related to climate change, search titles, abstracts, and keywords were used to obtain the data for this analysis from the Scopus database. This bibliometric analysis of a sizable and carefully chosen publication set of papers pertaining to climate change research offers a wealth of quantitative data: (1) the rise in the total output of publications related to climate change research as well as (2) some significant subfields; (3) the contributing journals and countries and their impact on citations; and (4) an analysis of title words intended to show the temporal evolution and relative importance of particular research topics. There has been a significant increase in the overall number of publications addressing climate change: between 2006 and 2022, the number of papers on climate change climbed by a factor of 10 and doubled every five to six years. These papers demonstrated the urgent need for additional study in order to increase our knowledge of the earth's climate system and our ability to anticipate future climate. Results indicate that the field has seen a rapid increase in publications and has become more interdisciplinary; The most productive authors in this field are located in the Aznar-Sanchez, J.A and Velasco-Munoz, J.F with each 5 documents publication in global climate change. The most productive institutions are Chinese academy of sciences with 37 documents publication, university of chinese academy of sciences with 19 documents publication and unicersidad de Almerfa with 15 documents publication in global climate change field. The results showed a rising trend in

publications and proposed many topics, primarily exposure, sensitivity, drought, and flood as a result of how climate change impacts economic vulnerability. According to our research, the number of publications about global warming and climate change has quadrupled roughly every five years. Articles pertaining to climate change are growing at an exceptionally rapid rate when compared to the expansion of science as a whole. Between 2006 and 2022, the total amount of articles covered by Scopus nearly doubled in just 17 years.

4. Concerns and issues global climate change research

4.1. The challenges of policy and regulation

Businesses can sell their licenses to other businesses if they are able to cut their emissions more than is necessary. Making an attempt to use energy more wisely without compromising productivity is known as energy efficiency. comprises improved manufacturing techniques, new technologies, and regulations to promote resource efficiency. Increasing energy efficiency can lower greenhouse gas emissions, lessen reliance on fossil fuels, and result in long-term financial gains from energy savings. The circular economy strives to eliminate waste and optimize the reuse of resources such as designing recyclable products, recycling materials, and limiting the usage of natural resources. Through waste reduction and a decrease in the need for fresh natural resources, the circular economy idea helps ease environmental stress. The process of switching from fossil fuels that emit carbon dioxide to renewable energy sources like biomass, the sun, wind, and water is known as the 'renewable energy transition.' Energy resources are more long-term sustainable when there is less reliance on fossil fuels, which also lowers greenhouse gas emissions. There are multiple linked concepts involved in global climate change. Research on global climate change brings up a number of policy and regulatory issues that must be resolved in order to meet mitigation and adaptation targets. These issues include the lack of confidence in impact estimates and practical solutions, the difficulty of coming to a global consensus on mitigation targets and goals, and the need to shift energy models to renewable energy sources without upsetting economic stability. Climate change affects include altered rainfall patterns and a rise in the frequency of natural catastrophes including floods, storms, and droughts. These effects can be mitigated and adapted to through the development of efficient adaptation strategies for policy makers. Figure 9 illustrates a number of key ideas related to global climate change:

4.2. Risks to human health: Awareness and ignorance

Human health may be directly impacted by one's knowledge or lack thereof of global climate change research concerns. Lower levels of exposure to air pollutants can increase the risk of respiratory and cardiovascular diseases due to a lack of knowledge about climate change and the air pollution it causes. Rising global temperatures can cause people to become ill from heat exhaustion and dehydrate more easily if they are not aware of them and are not prepared for severe heat waves. Being ill-prepared

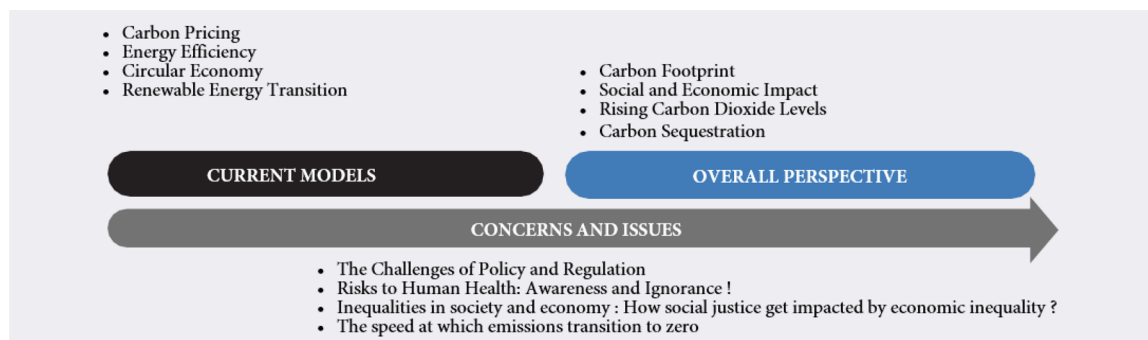


Figure 9. Global climate change concept.
Source: Authors (2023).

for and ill-equipped to deal with natural disasters like floods, storms, or forest fires can have negative effects on one's health. This is because there is insufficient understanding of the connection between climate change and extreme weather. The effects of climate change on society and the economy include increasing sea levels, declining agricultural output, and unequal resource access. Human activity, particularly the combustion of fossil fuels, deforestation, and industrial processes, is the primary source of the increased amounts of carbon dioxide (CO₂) in the atmosphere. In order to lower greenhouse gas emissions, carbon sequestration is removing and storing carbon from the atmosphere. This is done using a variety of techniques, including plants, forests, carbon capture and storage (CCS) technology, and other methods.

4.3. Inequalities in society and economy: how social justice get impacted by economic inequality?

Inequalities are the root cause of climate justice: Compared to wealthier nations and individuals, who use far more energy than is necessary for a livable standard of living, the most politically, culturally, and economically marginalized communities and nations use far less energy based on fossil fuels and bear far less responsibility for creating environmental problems. According to O'Brien & Leichenko (2000), climate injustice also refers to the reality that different countries and people are affected by climate change or disruptions in very different ways. This is further exacerbated by the cumulative impacts of globalization, which work to disadvantage the most vulnerable people. It is necessary to comprehend human wealth, power, and privilege disparities in order to comprehend climate disruptions and how to handle the potentially catastrophic problems caused by climate change. Social justice may suffer as a result of economic disparity in the community. People from lower socioeconomic backgrounds may be more vulnerable to the negative effects of climate change, including increased severe temperatures, air pollution, and the spread of illness. When jobs in industries that are more disaster-resistant are in higher demand and employment in sectors that are less affected by climate change, economic sectors may shift as a result. A significant upfront investment may be necessary when switching to clean, green energy sources.

4.4. The rate of emission reduction to zero

The earth's ecosystem's sustainability is under risk due to the extensive effects of global climate change, which have led to extreme weather patterns and increasing sea levels. The cost of reducing emissions is constant, not changing in line with advances in technology or shifts in the composition of the economy. The current analysis ignores the fact that the model represents the decrease of carbon dioxide emissions as a combination of structural and end-of-pipe measures, but the measures for methane and nitrous oxide are only end-of-pipe (i.e. to prevent emissions from rising again). The goal of being carbon neutral, or reducing emissions to zero, is to achieve equilibrium between the amount of greenhouse gases released into the atmosphere and the amount of emissions absorbed or reduced. In order to lessen the severe effects of rising global temperatures—such as extreme weather, rising sea levels, and dwindling biodiversity—we must achieve carbon neutrality. Achieving zero emissions lowers the danger of biodiversity loss and protects ecosystems, particularly forests, which act as natural carbon sinks. To achieve zero emissions, a major step is to switch from fossil fuels to renewable energy sources like wind and solar power. Large-scale carbon emissions, such those from coal-fired power stations, can be partially captured and stored with the aid of carbon capture and storage (CCS) technology.

5. Conclusion

We show in this paper that leading nations are gradually handing over control of global climate change research to poor nations. Research specialization at the national level is becoming more diverse as developing nations prioritize applied themes while developed nations prioritize basic research and global policies. Using a bibliometric approach, this study examined the traits of publications, research foundations,

research hotspots, and the evolutionary paths of studies on climate change from 2006 to 2022. Through the application of bibliometric techniques, this work has employed global climate change to shed light on historical developments and trends. This approach is beneficial since it uses statistical and mathematical techniques to perform a quantitative examination of a substantial volume of literature. The review has demonstrated the growing interest in integrated climate change research. Since 2006, the field of resilience has grown quickly. Biases and methodological constraints can be present in scientific research that use bibliometric analysis. Selected keywords are the only criteria used by the data collected from the scopus to retrieve journals and publications. The number of publications and citations may differ somewhat because the data was retrieved on a certain date. This may be explained by an increase brought about by the indexing of a new journal, issue, or articles within the chosen time frame (2006–2022). The analyses may contain linguistic bias because these keywords were in the English language. Research has shown that climate change is a crucial notion in relation to natural hazards, social-cological systems, and global environmental change. The countries with the highest number of published papers in the field were China, Spain, and the United States (US), according to the statistics. In the collaboration of international organizations, China is a major player. A substantial body of co-cited works from 2006 to 2016 established the groundwork for future research in the area.

During this time, study concentrated on how climate change affected the ecological environment, started to suggest various responses, and developed a set of refined research techniques. There was an increase in the growth rate of published papers from 2017 to 2019. Aside from being a very interdisciplinary endeavor, research on climate change involves active collaboration across numerous nations. On the other hand, if fresh issues of 'articles in press' are allocated for the next year 2023, the number of articles may fall concurrently. In order to filter out unnecessary material and capture the main ideas in the literature on catastrophe and climate change resilience, it is advised to add new databases and journals and conduct a more thorough thematic/content analysis. The Intergovernmental Panel on Climate Change (IPCC) produced an assessment that established the standard scientific reference for studies on climate change and its effects. Ultimately, considering the present direction of the study, we provide a list of future research directions on climate change and carbon sinks. In order to gain a deeper understanding of the global trends and tendencies that have arisen in the field of climate change and carbon sink research over the past 16 years, this study gives an extensive analysis of that research. It also serves as a valuable resource for future research in this area. In the past ten years, academic scholars have published research articles expressing worry about the impact of climate change on socioeconomic vulnerability, in addition to politicians. Our subfield study shows that climate modeling is the second most important subfield in climate change research, with research connected to continental biomass coming in first.

This study found that four concerns and problems with studies on global climate change include (1) the challenges of policy and regulation; (2) risks to human health: awareness and ignorance! ; (3) Inequalities in society and economy: how social justice get impacted by economic inequality? ; (4) the speed at which emissions transition to zero. The study of oceanic water, the consequences of climate change, and continental water (lakes, rivers, rainfall) comes next. Although the hazards, vulnerability, and mitigation of global warming are relatively low, their proportion of publications has grown dramatically since 2015. China is the country that does the most quantitative research on climate change, followed by Spain and the United States. Fourth and fifth place go to Australia and Brazil, then Italy and Germany. The UK has regularly generated the most widely recognized scientific publications on climate change when compared to other countries, according to all three citation-based indices. The title word analysis demonstrates how the phrase 'climate change' gains traction over time. It is evident that the writers are using a term more frequently that actually suggests human causes of global warming. This work represents an initial effort to map all of the literature on climate change. To examine and provide a quantitative overview of the research topic, more bibliometric research is necessary. Future studies ought to concentrate on in-depth examinations of more specialized subjects, such as how global warming affects forests, fisheries, and agriculture. The idea of global climate change is intimately associated with initiatives aimed at lowering greenhouse gas emissions and mitigating the adverse effects of these emissions on the environment. The implementation of many strategies aimed at mitigating the effects of climate change include carbon pricing, energy efficiency, the circular economy, and the shift to renewable energy

sources. In order to reduce greenhouse gas emissions, carbon pricing is an economically sound way to impose levies on carbon emissions. Governments can set overall emissions limits and issue tradeable emissions permits as the two primary methods of pricing carbon.

Authors' contributions

ASL Lindawati: Analyzed and interpreted the data; Wrote the paper, Performed the experiments; Conceived and designed the experiments; Analyzed and interpreted the data, writing, review and editing. Meiryani: Analyzed and interpreted the data; Wrote the paper, Performed the experiments; Conceived and designed the experiments; reagents, materials, analysis tools or data;

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Data availability statement

All data used in this study are available on Scopus at <https://www.scopus.com/term/analyzer.uri?sort=plf-f&src=s&sid=29d976b2815c8b45bbb4c49129d3d1d3&sot=a&sdt=a&sl=87&s=%28TITLE-ABS-KEY%28global+AND+climate+AND+c>

hange%29+AND+TITLE-ABS-KEY%28bibliometric+analysis%29%29&origin=resultslist&count=10&analyzeResults=Analyze+results. Additional documentation can be found at <https://drive.google.com/file/d/1ZrAa9wwZklga32yAXOk54Wm5uRIUjCFs/view?usp=sharing>.

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